"COMPARATIVE EVALUATION OF PERIOD REQUIRED FOR RECOVERY OF MAXIMUM BITE FORCE FOLLOWING OPEN AND CLOSED REDUCTION OF MANDIBULAR FRACTURE: A PROSPECTIVE CLINICAL STUDY"

Dissertation submitted to

SANTOSH DEEMED TO BE UNIVERSITY, GHAZIABAD, NCR, DELHI

In partial fulfillment of the requirement for the degree of

MASTER OF DENTAL SURGERY

In the speciality of

ORAL AND MAXILLOFACIAL SURGERY

Deemed to be University
(Established u/s 3 of the UGC Act, 1956)

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ACKNOWLEDGEMENT

This dissertation is the culmination of 2.5 years of hard work at Santosh Dental College & Hospital Ghaziabad. There are numerous people I wish to thank for contributing to this work.

Firstly, I would like to thank the Almighty for always having bigger plans for me and helping me to conquer my fears vivaciously.

I fall short of words to express my gratitude to my father, Mr. Jagadish Prabhale for always beholding me with tender, love and care and motivating me in all the ways to excel beyond my imagination. I am highly indebted to my mother Mrs. Madalasa Prabhale who taught me to never give up in tough times.

A profound sense of gratitude binds me to my guide, my mentor Dr. Amit B. Lall, Professor & Head, Department of Oral and Maxillofacial Surgery, Santosh Dental College & Hospital, who has been my backbone in all academic endeavours. His determination have constantly refined my clinical and academic deeds. He relentlessly empowers me to improvise my clinical acumen within me and the spoken and unspoken fundamental dictums of surgery. His diligence and aspirational perception towards his work never cease to inspire me. These are the virtues I wish to imbibe within me in the forthcoming years. His invaluable advice, ingenious insight, expert guidance, and his caring support have made this study possible in its entirety.

I wish to express my altitude sense of gratitude to my co-guide Dr. Mayank Singhal, Professor, Department of Oral & Maxillofacial Surgery, Santosh Dental College & Hospital, for his generous and useful support in the completion of this work. His remarkable insight and profound knowledge have uplifted my intellectual ambitions. He always welcomed my work with kind, positive and distinctive inputs effortlessly.

I wish to express my sincere gratitude to Dr. Lokesh Chandra, Professor, Department of Oral and Maxillofacial Surgery, Santosh Dental College & Hospital, for his wisdom, constant support, and encouraging words, which motivated me to complete my research work. His invaluable guidance has greatly contributed to shaping and refining my surgical skills.

I wish to record my thanks to Dr. Anupam Bhardwaj, Reader, Department of Oral & Maxillofacial Surgery, Santosh Dental College & Hospital, for his constant support and motivation. His words of wisdom guided me throughout my journey.

I express my heartfelt thanks to Dr. (Prof.) Akshay Bhargava, Dean and Principal, Santosh Dental College & Hospital, who provided me, this learning opportunity, which pushed me to go beyond my limits and dream for the best. His valuable insights made a strong impression on me and my work.

My deepest regards to Dr. P. Mahalingam, Chairman, Santosh Deemed to be University, for providing me with all the facilities for completion of this research endeavour. I also express my sincere thanks to all the teaching and non-teaching staff for their support throughout this endeavour.

I would extend my heartfelt gratitude to my seniors Dr. Tanya Kusum, Dr. Priyanka T, Dr. Jahanvi Mishra and Dr. Sonakshi Singh for teaching me righteousness, discipline and resilience on this rocky endeavour.

And lastly I would like to extend a big thanks to my colleagues Dr. Rani Raginee Rajhans, Dr. Deekksha Baghel, Dr. Prakriti Bhardwaj, Dr. Rajiv Kumar Singh and my lovely juniors Dr. Akriti Singh, Dr. Sreejita Mukherjee, Dr. Puja Agarwal, Dr. Harshita Sharma for being my pillar of strength through all the tough times and prepping me to stand tall like a warrior.

Thanking you…

Dr. Prabhale Pratibhchandra Jagdish

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LIST OF ABBREVIATIONS

S. NO.	ABBREVIATIONS	FULL FORM
1.	OPG	Orthopantomogram
2.	CT	Computed Tomography
3.	3D	3 - Dimensional
4.	POW	Post Operative Week
5.	IMF	Inter-Maxillary Fixation
6.	EMG	Electromyography
7.	TOW	Trans-Osseous Wire
8.	MVBF	Maximum Voluntary Bite Force
9.	QOL	Quality Of Life
10.	GOHAI	General Oral Health Assessment Index
11.	MMF	Maxillo-Mandibular fixation
12.	ORIF	Open Reduction and Internal Fixation
13.	RDSO	Research Designs and Standard Organisation
14.	CR	Closed Reduction
15.	LA	Local Anesthesia
16.	GA	General Anesthesia
17.	OLED	Organic Light Emitting Diode
18.	RTA	Road Traffic Accident

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INTRODUCTION

Trauma to the maxillofacial complex is functionally, aesthetically, and psychologically debilitating to the patient. A deformed face not only leads to difficulty in speech, swallowing, vision, but also leads to social anxiety and depression. Rehabilitation of maxillofacial trauma is constantly evolving, focusing especially on restoration of function and form by incorporation of latest available resources. The ability of a patient to masticate reduces drastically even after a minor dentoalveolar surgery. Maxillofacial intervention leads to reduction of masticatory efficiency significantly and the return to normal function which is sparingly discussed in literature. Hence, the return to function is important for improvement of the masticatory efficiency since it contributes to the improvement of general physical health of the patient. Mandibular fracture is the second most commonly occurring fracture next to nasal bone fracture when considering facial fractures. It is the tenth most commonly occurring fracture when considering the frequency of bone fractures of the whole body. Mandibular fracture represents a high percentage of all facial fractures.[1]

Mandible plays a vital role in functions such as chewing, speaking, and breathing. Due to its functional importance, the recovery of the mandible, particularly the ability to restore normal bite force, is critical for both physical and psychological well-being. Effective treatment of mandibular fracture is paramount in restoring not only the bone's structural integrity but also its functional capabilities. The energy required to fracture the mandible ranges from 44.6-74.4 kg/m, which is about the same as the zygoma and about half that for the frontal bone. It is four times as much force is required to fracture maxilla. Mandibular angle and condyle fractures are common, accounting for 23% to 42% of all mandibular fractures.[2]

Interpersonal violence, falls, sports injuries, work accidents, and traffic accidents are common causes of mandibular fracture, which can result in malocclusion, temporomandibular joint disorders, and difficulty in chewing, ultimately leading to a poor quality of life. Early recovery of these functions is crucial for a better quality of life. Mandibular fracture can be managed using two main techniques: open reduction and closed reduction. Open reduction involves surgically accessing the fracture site to reposition the bone and secure it with plates and screws. In contrast, closed reduction utilizes non-surgical methods such as the application of arch bar or wires to stabilize the fracture by intermaxillary fixation. While both techniques aim to achieve similar functional outcomes, including the restoration of bite force, the time required for full recovery varies between patients and technique of intervention. Immediate intervention is crucial to minimize complications and improve recovery.[3]

Weakened load-bearing capacity due to trauma to the oral cavity and surrounding structures can result in significant changes in a patient's ability to masticate following maxillofacial intervention. Masticatory function is frequently reduced after mandibular fractures, leading to difficulties with food intake (67%) and diet modification (55%). The amount of force required to counteract mandibular angle fractures has been estimated using maximum voluntary bite force measurements, which can reach up to 50 kilo-pounds (kp) in healthy adult males.[4]

The magnitude of the maximum voluntary bite force is indicative of the functional well- being of the stomatognathic system, and it is the outcome of the harmonious interplay between the jaw elevator muscles and the biomechanics of the jaw.[5]

The primary therapeutic goal for managing mandibular fracture is to restore original form and function with minimal discomfort and morbidity. Evolution of mandibular fracture treatment has led to various approaches, including maxillomandibular fixation, introduced by Guglielmo Salicetti in 1492 and popularized by Gilmer in 1887, and open reduction using an iron loop, introduced by Buck, Gilmer, and Luhr. The current preferred approach, as described by Champy et al. involves, non-compression mono-cortical plates in specific regions known as "Champy's lines of osteosynthesis."[6]

To provide stable fixation for mandibular fractures and osteotomies, various mini-plating systems have been developed. However, conventional miniplate systems have a drawback of perfect adaptation of the plate to the underlying bone. Adequate adaption of plate and underlying bone is necessary to maintain the fractured segment alignment and healing. In conventional bone plating systems, stability is attained by compressing the fixation plate to the bone with the screw head. Closed techniques do not ensure adequate anatomic reduction of the fracture and leave an architectural aberration in the mandible (malunion).[7]

Numerous clinical studies have demonstrated the potential and efficacy of the miniplate in the treatment of mandibular fractures since its introduction.[8] The range of mandibular motion, occlusion, maximum occlusal forces, and the activity of masticatory muscle are the four main determinants of masticatory function.[9]

The relationship between bite force, age and sex has been a topic of controversy. While certain investigations have reported no gender-based discrepancies, others have demonstrated that males exhibit higher bite force compared to females.

Bite force has been observed to increase with age and after a certain age, it begins to decline; however, the exact age at which this shift occurs is yet to be determined.[10]

Despite the importance of masticatory muscle forces in dental occlusion after treating mandibular fractures, little attention has been paid to this aspect. A simple way to assess -

masticatory function is by measuring the maximum occlusal force, which is often reduced when there are fractures in the mid-face or mandible.[11]

The maximum bite force represents the capacity of mandibular elevator muscles to exert the highest level of strain on the mandibular teeth against the maxillary teeth, in favorable circumstances. Gnathodynamometers and force transducers are among the methods utilized to measure bite force. If occlusal force has some relation to skeletal architecture, then one might expect open treatment to enhance the ability of the masticatory system to restore bite forces after mandibular fracture.[12]

In a comparative study by Ellis III E and Throckmortan GS (2001), the maximum voluntary bite force was evaluated in patients treated by ORIF (Group A, no. of patients = 64) and closed reduction (Group B, no. of patients = 91). They concluded, the maximum voluntary bite forces for patients in both treatment groups do not differ significantly and showed significant recovery of maximum bite force from 6^{th} week to 6^{th} month postoperatively in both groups. [11]

But according to various literature, the proponents of open reduction and internal fixation claim faster restoration of occlusal function, optimized repositioning of fractured segments and economic advantages due to reduced recovery time and return to work earlier. The proponents of closed treatment claim procedures to be less traumatic with preservation of vascularity of the trauma site along with facilitating shorter hospitalization stay.[14]

Masticatory efficiency seems to be a reliable indicator for post-operative quality of life (QOL). Restoration of normal bite force is a key indicator of functional recovery in patients treated for mandibular fractures and is essential for evaluating their post-operative quality of life.

Forces applied by the masticatory muscles in dental occlusion (i.e. bite force) following treatment of mandibular fractures have received little attention. Bite forces are a relatively underexplored area after open and closed treatment of mandibular fractures. Maximum occlusal force is one parameter of masticatory function that is relatively easy to measure.[15] Determination of the period of recovery to maximum bite force subsequent to open and closed method of treatment of mandibular fracture, is important, so as to improve post-operative quality of life.

In this way, the measurement of bite force can provide useful data for the evaluation of jaw function and activity. Given its importance, evaluating how quickly maximum bite force restored post-surgery is crucial for understanding the effectiveness of different treatment modalities. However, a comprehensive comparison of the recovery periods for maximum bite force following open versus closed reduction remains lacking in the literature.

The aim of this study was to assess the period of recovery of maximum bite force after open and closed reduction of mandibular fractures using indigenous bite force measurement device post operatively, to compare two groups and with healthy individual. This prospective clinical study, identified significant differences in recovery periods between the two treatment modalities. The findings of this study, contributed to a better understanding of the post-operative recovery process, post-operative quality of life and helped in decision making for optimal patient care.

AIM AND OBJECTIVES

AIM:

To compare the period of recovery of maximum bite force following open reduction and closed reduction of mandibular fractures using indigenous bite force measurement device.

OBJECTIVES:

- To evaluate the maximum bite force generated during the post-operative period after open reduction and internal fixation of mandibular fracture.
- To evaluate the maximum bite force generated during the post-operative period after closed reduction of mandibular fracture.
- Comparison of maximum bite force generated between the two groups and with healthy individuals.

RESEARCH HYPOTHESIS

- **NULL HYPOTHESIS:** Period of recovery of maximum bite force is significantly equal after open and closed reduction of mandibular fracture.

- **ALTERNATIVE HYPOTHESIS:** Period of recovery of maximum bite force is faster after open reduction and internal fixation of mandibular fracture than closed reduction of mandibular fracture.

REVIEW OF LITERATURE

Bochlogyros PN (1985)[1] conducted a retrospective study to analyse 1,521 mandibular fractures in 853 in patients treated between 1960 and 1980. The research focuses on age, sex distribution, causes, anatomical distribution, treatment modalities, and complications of mandibular fracture. Lentrodt (1982) reported that mandibular fractures account for 55% of facial fractures, often occurring alongside midface injuries. Rowe and Killey (1968) classified fractures based on anatomical location and noted that the body and angle of the mandible are most frequently affected. Olson et al. (1983) analysed 580 cases and found that motor vehicle accidents and altercations were the leading causes, which aligns with author's findings in the present study. Melmed and Koonin (1975) reviewed 909 cases, emphasizing that young males are most at risk of mandibular fracture. Bernstein and McClurg (1977) studied 156 cases and highlighted the role of alcohol consumption in fracture occurrence. Schilli (1982) introduced compression plate osteosynthesis, which improved fracture stability. Müller et al (1969) discussed principles of osteosynthesis, noting the importance of proper fixation for preventing non-union. Author examined complications and revealed that open reduction had a higher risk of nerve damage. Overall, literature confirms that mandibular fractures are common, primarily affecting young men due to trauma. Advancements in surgical techniques, such as rigid fixation, have improved treatment outcomes while minimizing complications.

Cawood JI (1985)[14] conducted a comparative study and evaluated small plate osteosynthesis by comparing 50 successive cases of mandibular fracture treated by this technique alone with 50 successive cases of mandibular fracture treated by intermaxillary fixation. The plates showed considerable advantages over other forms of fixation in that they are small, malleable and easy to insert. Author revealed that, furthermore, they achieved a high degree of stability. The rate of recovery of normal jaw function and normal body weight is significantly greater than with patients treated by intermaxillary fixation.

Dean JS, Throckmorton GS, Ellis III E et al (1992)[26] conducted a preliminary study to evaluate maximum voluntary bite force and jaw muscle efficiency in pre-orthognathic surgery patients. Authors compared the ability to generate occlusal force between eighty-four patients (16 males and 68 females) with a variety of dentofacial deformities who had orthognathic surgery planned and were selected for the study sample. Fifty seven controls (39 males and 18 females) were included in the control population. Maximal and submaximal bite forces were measured at the incisor, right and left first molar bite positions, using a custom bite force transducer. Electromyographic activity (EMG) was recorded bilaterally from the anterior

temporalis, posterior temporalis, and masseter muscles during each bite, using self adhesive, disposable, pregelled Ag/AgCl bipolar surface electrodes placed over the bulk of the muscles. Author revealed that male controls tended to have higher maximum bite forces than female controls at the molar bite positions. Male and female controls had significantly higher maximum bite forces at all positions when compared with patients of the same sex ($P < .05$). Male patients also had significantly higher maximum bite forces than female patients at all bites. The maximum incisor bite force between male and female controls were not significantly different. Author also concluded, female controls tended to have higher EMG/force ratios than male controls for all muscles and bite positions, but only the right masseter during left molar bites was significantly different ($P < .05$). Male patients tended to have higher EMG/force ratios than male controls for all muscles and bite positions, but only the left anterior temporalis during right molar bites was significantly different ($P < .05$). Female patients tended to have higher EMG/force ratio than female controls for all muscles at all bite positions except the left masseter during right molar bites. Female patients had significantly higher EMG/force ratios than male patients for all muscles at all bite positions.

Tate GS, Ellis III E, Throckmorton G (1994)[4] conducted a study to evaluate the ability of patients with mandibular angle fracture to generate bite forces after open reduction and internal fixation using a custom bite force gauge. They included 35 male patients treated with open reduction and rigid internal fixation and 29 adult male were selected in control group for comparison with patients. The result of the study showed significant reduction in incisor and molar bite forces in the first six weeks postoperatively and no significant difference in incisor bite force after the 6^{th} postoperative week. However author reported, reduction in molar bite forces after the 6^{th} postoperative week. They concluded that molar bite forces on the fracture side were significantly less than the non-fracture side.

Ellis III E, Throckmorton GS, Sinn DP (1996)[13] conducted a study to compare morphologic parameters and voluntary bite forces preoperatively and postoperatively between control group and sample of patients with mandibular prognathism. They examined adaption of patient's bite forces following mandibular setback surgery. They divided the patients into two groups. In test group 24 patients with mandibular prognathism were selected and control group consisted of 24 healthy male subjects. Maximum bite force were made preoperatively and up to 3 years post operatively. Author revealed that before surgery maximum isometric bite forces and mechanical advantage of jaw muscles were significantly lesser than control group.

Renton TF, Wiesenfeld D (1996)[3] conducted a retrospective study of 205 well documented cases of mandibular fractures treated with open reduction and internal fixation, to assess mandibular fracture osteosynthesis. Authors assigned patients into three groups according to the type of fixation; 83 patients had miniplate fixation according to Champy's principles, 40 patients had miniplate fixation ignoring Champy's principles and 82 patients had trans-osseous wire (TOW) fixation. Preoperative variables (age, gender, mechanism of fracture, site of fractures, nerve function, associated injuries) and postoperative variables (duration of admission, duration of intermaxillary fixation (IMF), malocclusion, infection, dehiscence, union, and nerve function) were assessed and compared by authors. Authors revealed that the preoperative variables were statistically similar in all groups. The post-operative variables indicated a statistically higher complication rate for the trans-osseous wire group compared with the miniplate groups, and morbidity was reduced in the group following Champy's principles.

Talwar RM, Ellis E III, Throckmorton GS (1998)[15] evaluated the adaptations that occur in the masticatory system after treatment of bilateral fractures of the mandibular condylar process. They included twenty-two patients with bilateral condylar process fracture treated by open reduction and rigid internal fixation or closed reduction or a combination of these techniques. They inferred that patients after treatment had significantly increased mandibular plane, gonial angles and decreased facial axis angles. Patients depicted significant reduction in posterior facial height and moment arm length for the masseter and pterygoid muscles. Their investigation concluded that early recovery in mandibular range of motion, bite force and the distribution of masticatory muscle activity, noted after open reduction and rigid internal fixation, which facilitated the prevention of excessive functional overload of bilaterally fractured mandibular condylar processes.

Palmieri C, Ellis III E, Throckmorton G (1999)[17] conducted a study to compare mandibular and condylar mobility after open or closed treatment for fractures of the mandibular condylar process. Authors included, one hundred thirty-six patients (111 male, 25 female), 74 treated by closed and 62 treated by open method, in this study. They assessed, mandibular and condyle mobility at 6 weeks, 6 months, and 1, 2, and 3 years post-operatively, using a jaw-tracking device. Authors revealed that, patients treated by open reduction had significantly greater initial displacement of their condylar processes than the group treated by closed method. Authors observed uprighting and displacement of the condyles, more significantly in patients treated by open reduction than closed method. At 6^{th} postoperative week, patients treated by closed

reduction had some measures of mandibular mobility that were significantly greater than those in patients treated by open reduction. However, after the 6th postoperative week, there were minimal differences in mandibular mobility between groups. At 6th postoperative week, patients treated by open reduction had significantly greater vertical mobility of the condyle than patients treated closed despite less mouth opening. After the 6th postoperative week, patients treated by open reduction continued to have greater condylar mobility on the fractured side than patients treated by closed methods. Authors concluded that patients treated for fractures of the mandibular condylar process by open reduction had somewhat greater condylar mobility than patients treated closed. Authors also revealed that the more displaced condylar process, the more limited mobility of the mandible.

Ellis III E, Simon P, Throckmorton GS (2000)[18] conducted a study to compare the occlusal relationships after open or closed treatment for fractures of the mandibular condylar process. A preoperative panoramic radiograph was used to classify the level of the condylar process fracture into head, neck, and subcondylar region. Author included, 137 patients with unilateral fracture of the mandibular condylar process (head or neck or subcondylar region), 77 treated closed and 65 treated open, in this study. Standardized photographs of the patient's occlusion (frontal, right and left lateral) were obtained at 6 weeks, 6 months, and 1, 2, 3 years after treatment, to evaluate occlusion. The occlusion were examined or scored by a surgeon and an orthodontist. Authors reveled that, patients treated by closed techniques had a significantly greater percentage of malocclusion compared with patients treated by open reduction, in spite of the fact that the initial displacement of the fractures was greater in patients treated by open reduction. Authors concluded that more consistent occlusal results can be expected when fractures of the mandibular condylar process are treated by open reduction.

Ellis III E, Throckmorton GS (2001)[11] conducted a study to compare maximum voluntary bite forces using a bite force transducer in patients received open or close reduction of mandibular condylar fracture. They included one hundred fifty-five patients with unilateral mandibular condylar fracture in their study (91 treated with closed reduction and 64 treated with open reduction). Maximum voluntary bite forces were measured at 4 different tooth positions on 6th week, 6th month and 1st, 2nd, 3rd year postoperatively. Electromyography of masseter muscle was also assessed. Author concluded that maximum voluntary bite forces for patients in both treatment groups do not differ significantly and showed significant recovery of maximum bite force from 6th week to 6th month postoperatively. Author also revealed that electromyographic ratios were significantly greater on unaffected site.

Gerlach KL, Schwarz A (2002)[8] conducted a study to evaluate load resistance of mandibular angle fractures treated with miniplate osteosynthesis according to Champy. For comparison they included 22 patients with mandibular angle fracture and 15 adults as a control group. Maximum biting forces were evaluated and compared between the two groups at incisors, canines and molars postoperatively (1^{st} to 6^{th} week, post-op). The result showed that in comparison with control group, patients showed a significant reduction of bite forces in initial post-op days. Slightly increased bite forces from 1^{st} to 3^{rd} postoperative week were noted, while after 4^{th} postoperative week no significant reduction observed. But after 5^{th} postoperative week significant drop in maximum bite force were observed followed by an increase at 6^{th} postoperative week.

Koc D, Dogan A, Bek B (2010)[5] conducted a literature review on bite force and stated that Maximal Voluntary Bite force (MVBF) is an indicator of the functional state of masticatory system and the level of maximum bite force results from the combined action of the jaw elevator muscle modified by jaw biomechanics and reflex mechanisms. Authors stated that the measurements of bite force can provide useful data for the evaluation of jaw muscle function and activity. It is also an adjunctive value in assessing the performance of dentures. However these measurements are difficult and the reliability of the result depends on a number of factors such as presence of pain, temporomandibular disorders, gender, age, craniofacial morphology and occlusal factors. In addition to these physiological factors, recording devices and techniques are important factors in bite force measurements. Authors concluded that measurement of bite force has been a reliable method of assessing the biomechanical properties of masticatory system and the prosthetic system.

Agarwal M, Mohammad S, Singh RK et al (2011)[7] conducted a study to compare efficacy of the 2 mm locking miniplates versus 2 mm standard plates in the osteosynthesis of mandibular fractures. They included a total of 20 patients with 32 fracture sites. Patients were randomly divided into 2 groups, mandibular fractures treated with 2 mm locking plates (group 1) and treated with 2 mm non-locking plates (group 2). Clinical parameter and bite force measurements were made at 1^{st}, 3^{rd}, 6^{th}, week and 3^{rd} month post-operatively. Author concluded that the locking miniplates provide the advantage of a greater bite force, with clinical results almost similar to those seen with non-locking miniplate osteosynthesis.

Kshirsagar R, Jaggi N, Halli R et al (2011)[6] conducted a study in sixty volunteers (control group) and six isolated mandibular unilateral parasymphyseal fracture patients (study group) to measure the period required for recovery of maximum bite force following open reduction

and internal fixation. The bite forces were measured using bite force measurement appliance at 1st, 2nd, 3rd, 4th, 6th, 8th, 10th, and 12th week post-operatively from incisor, right molar and left molar regions. Author concluded that, incisor bite forces were reduced significantly in the 1st and 2nd post-operative weeks and regained significantly till 4th to 6th postoperative weeks. Bite forces in molar region took 6 to 12 postoperative weeks to regain maximum bite force, when compared with the volunteer group.

Singh S, Utreja AK, Sandhu N, Dhaliwal YS et al (2011)[10] conducted a study to assess the consistency and accuracy of a new novel bite force recorder (gnathodynamometer). Authors included 30 adult healthy subjects. Author revealed that mean values for maximal bite forces varied from 216 N to 740 N. They concluded that authenticated device can be used to assess the complex function of human bite force, which is the net resultant combination of functional response of various craniomandibular structures.

Varga S, Spalj S, Lapter V M et al (2011)[19] conducted a study to determine whether stabilization of maximum voluntary bite force (MVBF) occurs between 15 and 18 years of age in subjects with a normal occlusion, and to assess the influence of gender, body mass index (BMI), morphological occlusion, and jaw function measured by the number of occlusal contacts, overjet, overbite, maximal mouth opening, mandibular deflection during opening, sagittal slide between the retruded contact position and number of dental restorations. Authors included, 60 caucasian subjects, aged 15 years (15 males and 15 females) and 18 years (14 males and 16 females) with a neutral occlusion, balanced facial profile, absence of any previous orthodontic intervention. Bite force measurements were recorded using a portable occlusal force gauge on both the left and the right side of the jaw in the first molar region during maximal clenching. Authors concluded, in subjects with a neutral occlusion, MVBF could be best predicted using multiple regression from age and gender. The regression model accounted for 31.3% of the variance in maximum voluntary bite force (MVBF) ($P = 0.031$), with contribution of gender (17.9%) and age (7.9%). Morphological occlusion, jaw function, and BMI explained the remaining 5.5% of variance. While controlling for all other parameters, the independent contribution of gender to the prediction of maximum voluntary bite force (MVBF) was 16.2%, age (6%), number of occlusal contacts (3.2%), and BMI (1.3%).

Gupta A, Singh V, Mohammad S (2012)[23] conducted a prospective study to determine, the clinical stability and efficacy of 1 microplate combined with 1 miniplate in the management of mandibular fractures of the inter-foraminal region compared with the standard 2 miniplate treatment using bite force measurements. Authors included 20 patients, were treated for

isolated mandibular fracture of the inter-foraminal region. They were randomly divided into Group 1 (test group) and Group 2 (control group), with 10 patients per group. Group 1 underwent osteosynthesis using the combination of 1 microplate (subapical) and 1 miniplate (at the lower border). Group 2 underwent osteosynthesis using the standard 2 miniplate protocol. The bite force measurements were performed pre-operatively and post-operatively at each follow-up using a bite force recorder (follow-up was performed at 14th day, 6th week, 3rd month, and 6th month post-operatively). As a secondary outcome, the patients also were assessed for complications, such as infection, that might interfere with successful osteosynthesis at the fracture site. Authors revealed, statistically significant increase in incisor bite force was found in the both study groups compared with the preoperative bite force measurements. No statistically significant difference was seen in the incisor bite force of either group at the different follow-up visits. No statistically significant difference was seen in the molar bite force (right vs left) of the test and control group during follow-up. Molar bite force on the non-fractured side was greater than the fractured side in the both groups. Infection was seen in 1 patient (10%) in each group.

Serra CM, Manns AE (2013)[20] conducted a study to compare the maximum voluntary bite force measured by a digital occlusal force gauge (GM10 Nagano Keiki, Japan) between different opponent teeth, employing semi-hard or soft bite surfaces. Authors included a sample of thirty-four young adults with complete natural dentition in this study. The original semi-hard bite surface was exchanged by a soft one, which was made up of leather and rubber. Maximum voluntary bite force recordings were made for each tooth with both biting surfaces. Statistical analyses (student's t-test) revealed significant differences, with higher scores while using the soft surface across sexes and tooth groups ($P < 005$). Authors revealed, differential activation of periodontal mechanoreceptors of a specific tooth group, mainly conditioned by the hardness of the bite surface. A soft surface induced greater activation of elevator musculature, while a hard one induced inhibition more promptly. Authors concluded that, soft bite surfaces are recommended for higher reliability in maximum voluntary bite force recordings.

Sybil D, Gopalkrishnan K (2013)[9] conducted a study to determine the effect of mandibular fractures on the bite forces of 60 patients. The patients were followed up on first, fourth, sixth and ninth post-operative weeks. They concluded that the maximum bite forces in patients were significantly less as compared to control group. After the ninth post-operative week maximum bite force measured was 80% of the normal, in patients with isolated parasymphysis fractures. The values significantly reduced to >60% in fractures of angle and parasymphysis and >70%

in patients with fractures of parasymphysis and condylar complex. Authors stated that an inverse relationship was found between bite force values and number of fractures of the mandible. They conclusively appreciated lower bite forces and longer periods of normalization in patients who had fractures in regions exclusively associated with the masticatory apparatus namely, angle or condyle of the mandible.

Omeje KU, Rana M, Adebola AR (2014)[21] conducted a randomized prospective study to assess post-operative quality of life after open reduction versus closed reduction following mandibular fractures, from the patient's perspective. Authors included, fifty-six patients with mandibular fractures within the tooth bearing areas of the mandible in this study. Both groups were analysed pre-operatively and 1st day, 6th, 8th, week post-operatively regarding their post-operative quality of life (QOL) using the General Oral Health Assessment Index (GOHAI) questionnaire. Authors revealed that no significant statistical difference was found between the groups regarding overall quality of life. Patients managed by MMF were more affected by psychosocial and physical domains whereas patients managed by ORIF were more affected by the pain domain. Author also concluded that the treatment affects the psychosocial, physical and pain domain differentially. When both treatments are possible the patient should be enlightened on the advantages and disadvantages of both treatment modalities to guide the choice of treatment.

Pepato AO, Palinkas M, Regalo SC et al (2014)[2] conducted a study to examine effect of surgical treatment of mandibular fracture on electromyographic (EMG) analysis, bite force, mandibular mobility of 12 patients compared with 12 voluntary healthy control. The subject were divided into 3 groups, mandibular angle fracture (group 1), condylar process fracture (group 2), and control (group 3). The patients were followed up 2 months postoperatively. Authors concluded that group 1 and group 2 had an increase in bite force postoperatively. Group 1 presented regular decrease in EMG activity and group 2 presented an irregular pattern in EMG. Both the groups obtained high percentage of mandibular movements when compared with control group. Authors also reveals that a good functional recovery was achieved by group 1 and group 2 after two postoperative months.

Giri KY, Sahu P, Rastogi S et al (2015)[24] conducted a prospective randomized study to compare and evaluate the variation in recorded bite forces in patients with mandibular fractures undergoing open reduction and rigid internal fixation using standard 2.0 mm non-locking versus 2.0 mm locking miniplates. Authors included 20 adult patients with 31 mandibular fractures requiring an open reduction and internal fixation. The sample was divided into two

groups depending upon whether the patients received 2.0 mm non-locking (standard) or 2.0 mm locking mini plates for rigid fixation respectively. Bite force was evaluated at 2nd post-op day, 1st, 3rd, and 6th week post-operatively using an indigenous Bite Force Recorder, designed at RDSO (Research Designs and Standard Organization), Lucknow. Authors revealed that, a comparison between 2nd post-operative day vs 6th post-operative week values showed a significant increase in bite force in Group 1 (2 mm non-locking).

Kumar S, Gattumeedhi SR, Sankhla B et al (2015)[33] conducted a comparative study to assess the masticatory efficiency offered by new internal locking miniplates over conventional miniplates and to compare the stability of fractured mandibular fragments under functional load, when fixed with conventional miniplate and internal locking miniplate. Authors included twenty mandible fractured patients and fifty normal healthy individuals in this study. Comparative evaluation of bite force generated was performed between 10 cases treated with conventional miniplates and 10 cases treated with internal locking miniplates. Bite force generated by patients in mandibular fracture between symphysis and the angle of mandible was recorded using indigenous Bite Force Recorder, at incisor and molar regions preoperatively. The fracture fragments were fixed using the mentioned fixation techniques. Then same recording was undertaken on the 7th, 14th, 21st, 28th and 90th day postoperatively. Authors revealed that bite force generated by patients treated with locking plates at the 7th, 14th, 21st, 28th and 90th postoperative day was significantly higher as compared to those in patients treated with miniplates. Authors observed that the locking plate/screw system offers significant advantages over the conventional plating system. According to authors, there were no intraoperative difficulties associated with placement of the plate.

Ahmed SS, Rehman SA, Ansari MK et al (2016)[22] conducted a comparative study to evaluate role of 1.5 mm microplates and 2.0 mm standard miniplates in management of mandibular fractures using bite force as indicator for fixation recommendation. Authors compared the maximum voluntary bite force generated at different periods during mandibular fracture healing using miniplates and microplates as means of rigid internal fixation. Patients suffering from symphyseal, parasymphyseal and mandibular body fractures were selected and randomly treated using miniplate and microplate osteosynthesis by open reduction and rigid internal fixation (patients in Group I were treated by open reduction and rigid internal fixation using 1.5 mm microplates and in Group II using 2.0 mm miniplates). Thirty healthy volunteers in control group and fourty patients, with twenty patients in each study group (Group I and Group II), were included in the study. The average age of volunteers in control group was 26.3 years

(age range, 18 - 34), in patients of Group I was 30.6 years (age range, 18 - 55 years), in Group II was 30.7 years (age range, 19 - 55 years). Postoperative bite forces at intervals of 1st, 2nd, 4th and 6th week were recorded using a bite force recorder and compared with control group. Authors revealed that bite forces of the study groups were significantly reduced in comparison to control group at different time intervals postoperatively. There was a progressive improvement in the bite force with passage of time postoperatively. There was no statistical significance observed in the bite force of both the study groups at different intervals of assessment. Authors concluded that 1.5 mm microplates provide adequate stability comparable to miniplates for the treatment of fractured mandible and should be preferred over miniplates.

Rastogi S, Reddy M, Swarup A et al (2016)[25] conducted a randomized study to analyse the difference in bite forces in patients treated for mandibular fractures with 2.0 mm conventional and locking titanium plating system. Authors included twenty adult patients with isolated mandibular fracture, in this study. The patients were randomly allocated into two groups, Group I - 2.0 mm non-locking (traditional) and Group II - 2.0 mm locking plates. Bite force was evaluated at 1st, 3rd, and 6th week post-operatively using an indigenous bite force recorder, designed at the Research Designs and Standard Organization. Authors revealed that there was statistically significant increase in the bite force, between 1st and 3rd week post-operatively within the group comprising patients in whom locking plates was used and highly significant increase in bite force from 1st to 6th weeks of follow-up period. Authors also concluded that the rapid improvement of bite force values when locking plates were used implies that the locking plate can be used in preference to conventional plates, to achieve early mobilization with assured stability in the treatment of mandibular fractures.

Pal K, Sushmita R, Mitra GV et al (2017)[12] conducted a study to evaluate post-operative bite force in open and closed reduction of mandibular fractures on 60 patients. The subjects were divided into control group (80 healthy individuals), group 1 (30 surgically treated patients), and group 2 (30 conservatively treated patients). Bite forces were calculated at 5th, 7th, and 12th week post-operatively using customized gnathodynamometer and compared with control group. Author concluded that three months post-operatively, open reduction and internal fixation shows significantly better results in terms of higher bite force values than the closed reduction.

Abo Mustafa AA, El Dibany MM, Shokry MM et al (2017)[27] conducted a randomized controlled clinical trial to compare the bite force recovery in patients with mandibular angle fractures treated by one monocortical miniplate and two monocortical miniplates fixation.

Authors performed comparative evaluation of bite force generated, between seven cases treated with one monocortical miniplate and seven cases treated with two monocortical miniplates. Bite force generated by patients with mandibular angle fractures was recorded in incisor, premolar and molar regions pre-operatively, weekly for 6 weeks and then 3rd month postoperatively using pressure indicating film, and color calibration swatch scanner. Authors revealed that bite force increased gradually in both groups in the anterior region, premolar region (right and left) and molar region (right and left) during the follow up period except a drop in group I during the 5th post-operative week in the right molar region. Authors also concluded, no significant difference between the uses of either one or two miniplates osteosynthesis in fixation of angle fractures. The miniplate osteosynthesis had proven to be a suitable method for treating mandibular angle fractures.

Glória JC, Fernandes IA, Silveira EM et al (2018)[28] conducted a systematic review to evaluate comparatively, the difference in the bite forces of patients with mandibular fractures treated by locking or non-locking plates. Authors conducted a systematic review and a meta-analysis using four databases (PubMed, Virtual Health Library, Web of Science and Science Direct) without restrictions of publication date or language. Authors revealed that the overall results showed better performance in bite force for the locking plates when compared with the non-locking plates in the incisor region (mean deviation [MD]:1.18;95% confidence interval [95%CI]: 0.13–2.23), right molar region (MD: 4.71; 95%CI: 0.63–8.79) and left molar region (MD:10.34; 95%CI: 4.55 16.13). Authors also concluded that the results of this study indicated a better bite force result with the locking plates.

Mishra N, Priya A, Jaiswara C et al (2020)[29] conducted a comparative study to evaluate the effectiveness of locking 2.0 mm titanium plate in comparison to the conventional 2.0 mm titanium plate in fixation of mandible fracture and also to determine the difference in postoperative bite forces in mandible fracture patients managed with both the systems. Authors randomly divided thirty patients into two groups (I and II). Both the groups consisted of 15 patients each, who underwent mandibular osteosynthesis using locking and conventional (non-locking) 2 mm miniplates, respectively. Authors revealed, a statistically insignificant result in the following parameters: pain, swelling, paresthesia, infection, hardware failure, and postoperative occlusal bite forces. An increase in bite force is recorded at each follow-up (first, second, fourth postoperative week, and at third postoperative month) for both the groups. When occlusal bite forces were compared, group I showed greater mean bite force than group II at each follow-up. Authors also concluded that both locking and conventional miniplates are

equally effective in withstanding masticatory load. With locking plates/screw system having added advantage of higher initial stability and stiffness thereby minimizing the duration of IMF. Locking miniplates system was found to have less infection and hardware failure.

Patel S, Bhimani K, Narsingyani R et al (2022)[30] conducted a prospective randomized comparative study to compare and evaluate the efficiency of 2 mm 3D titanium miniplate versus 2 mm conventional titanium miniplates for management of anterior mandibular fractures on the basis of bite force measurements. Authors randomly allocated, sixty-six patients into two groups: Group I (Control) conventional miniplates and Group II (Study) 3D miniplate, who had anterior mandibular fractures. Bite force was measured using gnathodynamometer at three main regions: central incisor, right and left canine, and right and left first molar regions preoperatively and thereafter every post-op week till 6th postoperative week. Simultaneously, mouth opening, duration of surgery, post-operative infection, malunion/non- union, hardware failure, paresthesia, occlusal status, and wound dehiscence were observed. Authors revealed that an increase in bite force was noted at each subsequent follow up in both the groups across all sites. Authors also concluded, bite force is a reliable parameter to assess restoration of masticatory efficiency following open reduction and internal fixation (ORIF). 3D miniplates when used in anterior mandibular fractures management are efficient enough to withstand masticatory forces throughout the healing process, providing better stability of fractured segments against torsional forces during immediate post operative period.

Salunkhe SM, Kadam H, Nakhate M et al (2022)[31] conducted a case control study to evaluate the masticatory forces in patients treated for mandibular fractures and to assess the magnitude of damage to the masticatory system caused by the various mandibular fractures and the period required for their normalization. Authors equally divided thirty patients according to their fracture pattern into unilateral fracture and bilateral fracture of the mandible. The sample was composed of 30 isolated mandible fracture patients. Group 1 included 15 patients with unilateral mandible fracture and in Group 2 included 15 patients with bilateral mandible fracture, treated with ORIF (open reduction immobilization fixation) under general anesthesia, and Group 3 was a control group. Predictor variables were drawn from predefined intervals for three months postoperative (ninth POW). The condition of wound healing was checked, and masticatory forces are measured at the first, fourth, sixth, and ninth postoperative week and compared with a control group of the same age and gender. Authors suggested that the patient had lower bite forces relative to the control Group at all intervals. All patients showed a significant increase in the bite force values from the first to the fourth postoperative weeks,

increased significantly from fourth to sixth postoperative weeks, and from sixth to ninth postoperative week. Authors also concluded that fracture of the bilateral mandible has a stronger influence on bite force than unilateral mandible fracture and these fractures took a longer time to normalize.

Patil SS, Nilesh K, Chapi MK et al (2024)[32] conducted a clinical comparative study to evaluate the efficacy of microplates for managing undisplaced or minimally displaced anterior mandibular fractures, and to compare them with miniplate osteosynthesis in terms of occlusal stability, fracture fixation and biting efficiency using a bite force measurement device. A total of 40 patients diagnosed with undisplaced or minimally displaced symphyseal and parasymphyseal fractures were randomly assigned to two study groups (Group 1 and Group 2). Patients in Group 1 (microplate group) were treated with two 0.8 mm microplates, whereas patients in Group 2 (miniplate group) treated using two 2.0 mm miniplates. Bite force values were recorded in 30 healthy individuals (control group) to establish baseline values. Bite force measurements were recorded using a digital bite force recorder (HARIOM Electronics, Vadodara, India). In the study groups, the bite force was measured at the incisor, right molar and left molar region before surgery and at 1^{st}, 2^{nd}, 4^{th}, and 6^{th} postoperative weeks. A single bite force measurement was recorded for the control Group at the incisor, right molar and left molar region. Authors revealed that both groups demonstrated a progressive improvement in the bite force. However, the bite force values recorded at the 2^{nd}, 4^{th}, and 6^{th} postoperative weeks were comparatively lower in the microplate group. At 6^{th} postoperative week, the bite force values were lower in both study groups in comparison to the control group. Authors concluded, the use of microplates in the management of undisplaced or minimally displaced anterior mandibular fractures results in a reduction in the recovery of biting force in comparison to the conventional miniplate system.

MATERIALS AND METHODSV

MATERIALS:

SOURCE OF DATA:

Twelve patients with mandibular fracture within the age group of 21 to 60 years who reported to the Department of Oral and Maxillofacial Surgery, Santosh Dental College and Hospitals, Ghaziabad and allied private hospitals were included. The study was carried out over a duration of two years. Written informed consent was taken from all patients prior to the treatment (Annexure - 5). The protocol for this study was approved by the institutional ethical committee and details of the same are attached (Annexure – 1).

SAMPLE SIZE:

In this study 12 cases of mandibular fracture were equally divided into two groups as followed:
Group 1 - patients treated with open reduction and internal fixation (ORIF).
Group 2 - patients treated with closed reduction (CR).
Voluntary Control Group (healthy individuals) - 12 voluntary healthy individuals were selected as a control group with a range of 21 to 60 years for comparison with mandibular fracture subjects.

STUDY DESIGN:

This was a prospective clinical study.

SELECTION CRITERIA

INCLUSION CRITERIA:

- Patients with mandibular fracture in the age group of 21 to 60 years, who consented for participation in the clinical study and consented for treatment.
- No sex predilection.
- Patients who were medically fit for surgery and with no debilitating systemic diseases.
- Sufficient intact bilateral dentition which would permit treatment modalities and bite force assessment for 1^{st}, 3^{rd}, 6^{th} and 9^{th} postoperative weeks.

EXCLUSION CRITERIA:

- Patients not fulfilling inclusion criteria were excluded.
- Medically compromised patients who were unfit for any surgical intervention (ASA IV, ASA V).
- Geriatric patients (above 60 yeasrs) or denture wearers (edentulous patients).
- Pediatric patients or patients who were in mixed dentition phase (below 20 years).
- Patients with missing dentition (incisors or molars).
- Patients who were diagnosed with any TMJ pathologies and dysfunction or any masticatory muscle dysfunction/syndrome.
- Patients who refused for participation in the clinical study and consent for surgery.

METHODS:

STUDY DESIGN AND SURGICAL PROCEDURE:

A detailed case history was obtained, and thorough clinical examination supported by radiographic assessment was done as per the trauma evaluation proforma and mandibular fractures were classified (Annexure - 3). Patients were educated about both the treatment options in detail (open reduction and closed reduction) along with the associated complications and the follow up visits required for study purpose. Patients in Group 1 for open reduction of mandibular fractures were admitted and posted for surgery under local anesthesia or general anesthesia (LA/GA) after routine blood investigations and pre-anesthetic evaluation were completed. Extraoral and intraoral preparation was done with betadine and standard aseptic draping protocols were followed. Ivy Eyelets / Erich's arch bar / IMF screws were used for obtaining occlusion bilaterally and IMF was done intraoperatively. The site was exposed either intraorally or extraorally using an indicated appropriate approach. Adequate anatomic reduction of the fractured segments was carried out followed by fixation of the fractured site using titanium plates and screws (2mm, 2.5mm Orthomax Titanium Plates) and titanium screws (Orthomax). Closure was done in layers after debridement and adequate haemostasis was achieved. Patients in Group 2 were treated on an OPD/IPD basis with intermaxillary fixation under LA/GA for duration of 4-6 weeks using either arch bars, eyelets or IMF screws. Post-operative evaluation was carried out in both the groups at regular intervals on the 1^{st}, 3^{rd}, 6^{th} and 9^{th} post-operative week.

BITE FORCE MEASUREMENTS:

All bite force measurements were recorded at the 1st, 3rd, 6th and 9th week postoperatively using an indigenous digital bite force measurement device. While recording the bite force, the patients were seated with their heads upright, looking forward, and in an un-supported natural head position. The subjects were instructed to bite on the bite-fork as forcefully as possible three times in succession, resting for five seconds between each bite. The largest value was chosen as the maximum bite force. Bite forces were measured at the central incisor, as well as the right and left molar regions (Annexure – 4).

BITE FORCE DEVICE:

An affordable, wireless, modular instrument had been developed to precisely measure bite forces (Fig 1). Two basic structures make up the measurement system head and body. The body encases firmware for data collecting, and the head has a sensor for measuring the bite force. The body is made up of polypropylene plastic, having dimensions 116.56 mm × 34.5 mm × 34.50 mm. The body has a switch on and off button, and a charging unit in which any standard USB charger will work.

Bite force device contains lithium-ion batteries (full charging time ~1.5 hours) and the device can be operated for a week. The body has an Organic light-emitting diode (OLED) screen, where we can see the output force in newton, pressure in kilopascal, and weight in grams. The body has a logo on top of the OLED screen and a small torch at top of the body over the logo. A torch helped in positioning the head part better intraorally. The head part of the device was made up of stainless steel, having dimensions 69.12 mm × 10 mm × 6.6 mm. It consisted of two plates of stainless steel carefully designed and accurately machined. A biting portion of the head, secured with a circular biting platform of dimension 10 mm diameter and 18 mm height. The compression forces were measured by a commercially available piezoresistive sensor called the FlexiForce force Sensor (Tekscan, Boston, MA, USA). Additionally, it can function between −40°C and 60°C. For precise measurements, it was crucial to apply forces just to the sensor's 9.53 mm diameter detecting region.

After application of force to the sensor (the FlexiForce force sensor), the resistance of the sensing element changed and was inversely proportional to the applied load. This resistance change (analog signal), then transmitted to the microcontroller board where it was converted into digital values by an Arduino UNO development board.

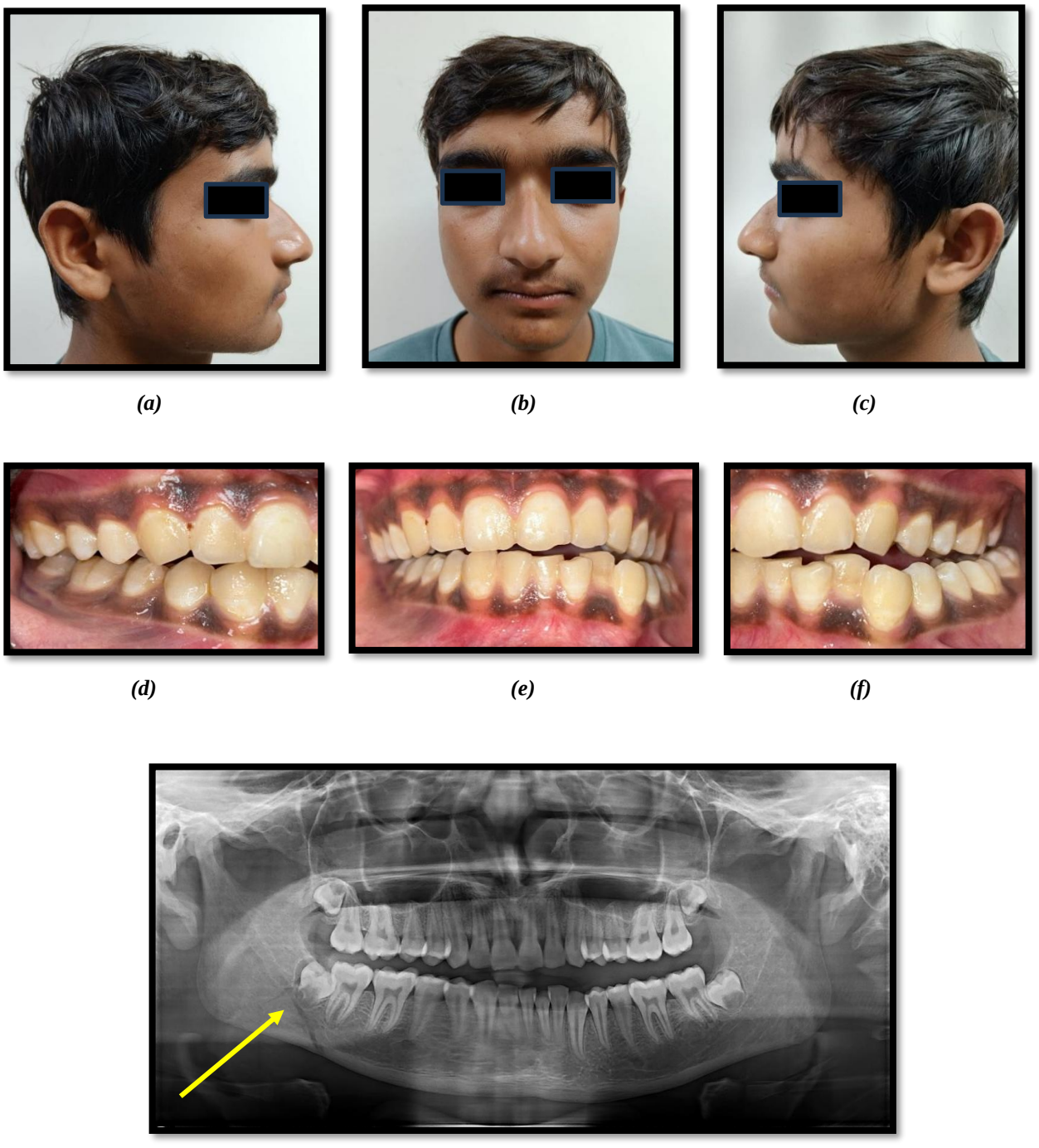
The software on the microcontroller board analysed these digital values and produced force values. The results, in term of bite force values were immediately visible on the OLED screen of the device.[16]

Fig 1 : Bite force measurement device

STATISTICAL ANALYSIS

The data for the present study was entered in the Microsoft Excel 2007 and analysed using the SPSS statistical software 23.0 Version. The descriptive statistics included mean, standard deviation frequency and percentage. The level of the significance for the present study was fixed at 5%. The intergroup comparison were done using the independent t test/Mann Whitney U test and intragroup comparison between time intervals will be done using the Wilcoxon signed rank test/Paired t test. The ordinal variable were compared using the Chi square test. The Shapiro-Wilk test was used to investigate the distribution of the data and Levene's test to explore the homogeneity of the variables.

REPRESENTATIVE CASES

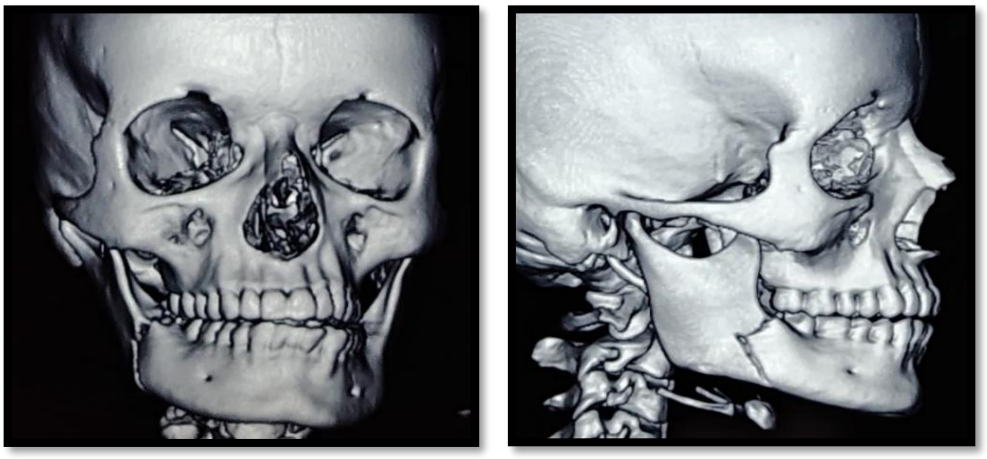


(a) *(b)* *(c)*

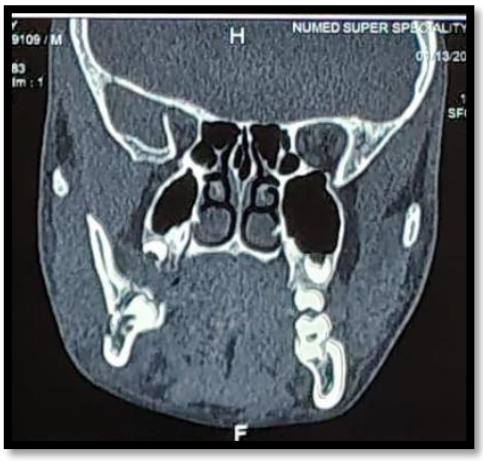
(d) *(e)* *(f)*

(g)

Fig 2 : Group 1 – Pre-operative images (a) Right lateral profile (b) Frontal profile (c) Left lateral profile (d) Right lateral occlusion (e) Frontal occlusion (f) Left lateral occlusion (g) OPG (arrow depicting right mandibular angle fracture)



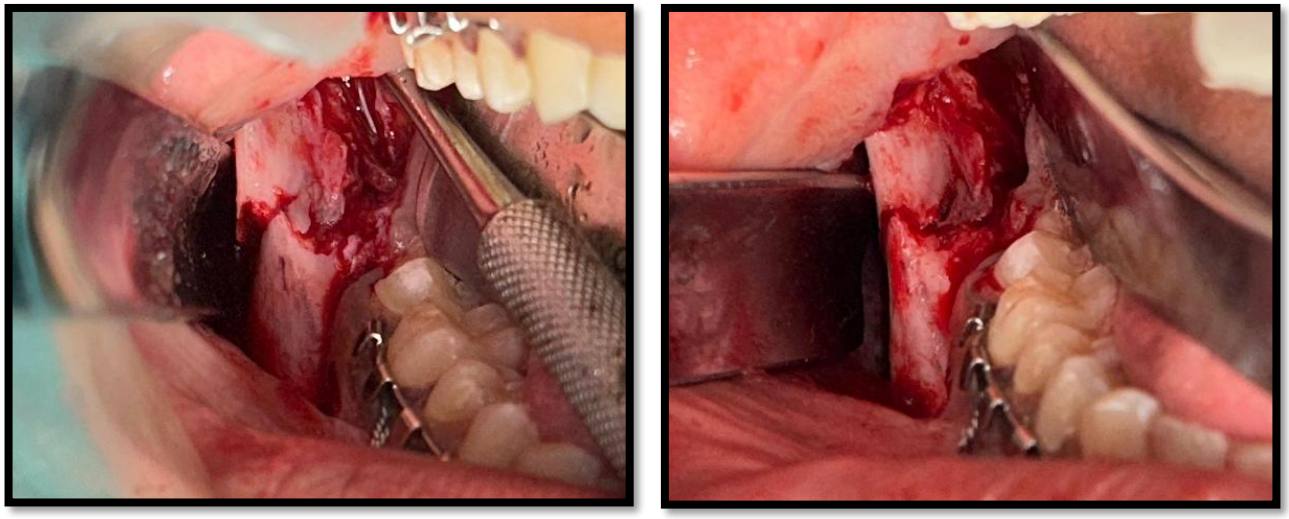
(a) *(b)*



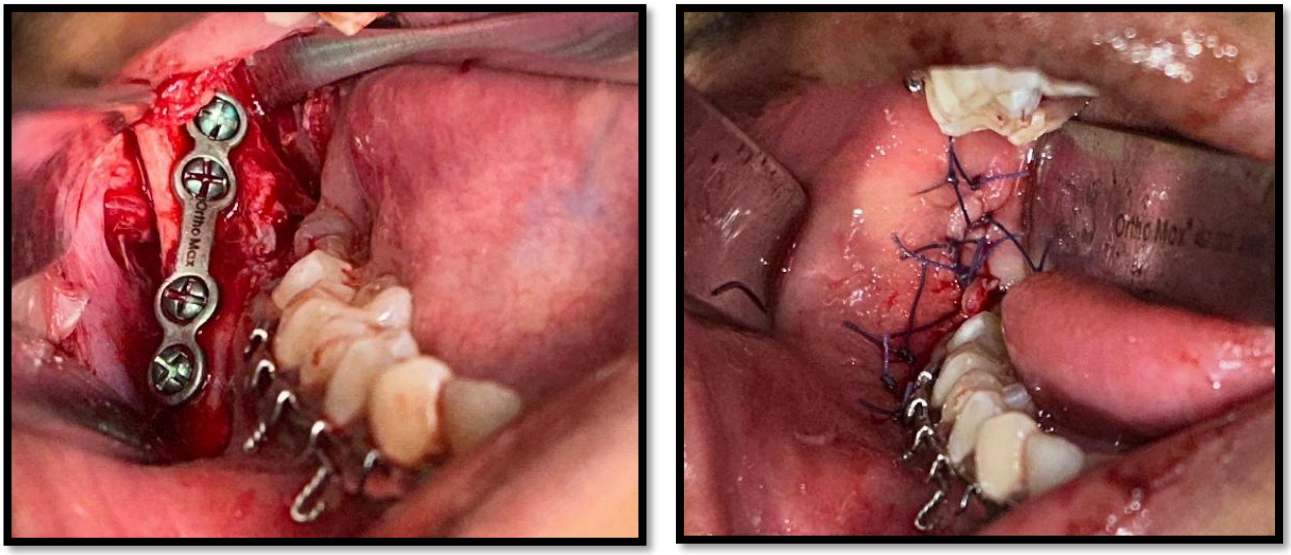
(c)

(d) *(e)*

Fig 3 : Group 1 – Pre-operative radiographs (a) CT face with 3D reconstruction (frontal view) (b) CT face with 3D reconstruction (lateral view) (c) CT coronal section (d) CT axial section (e) CT sagittal section



(a) *(b)*



(c) *(d)*

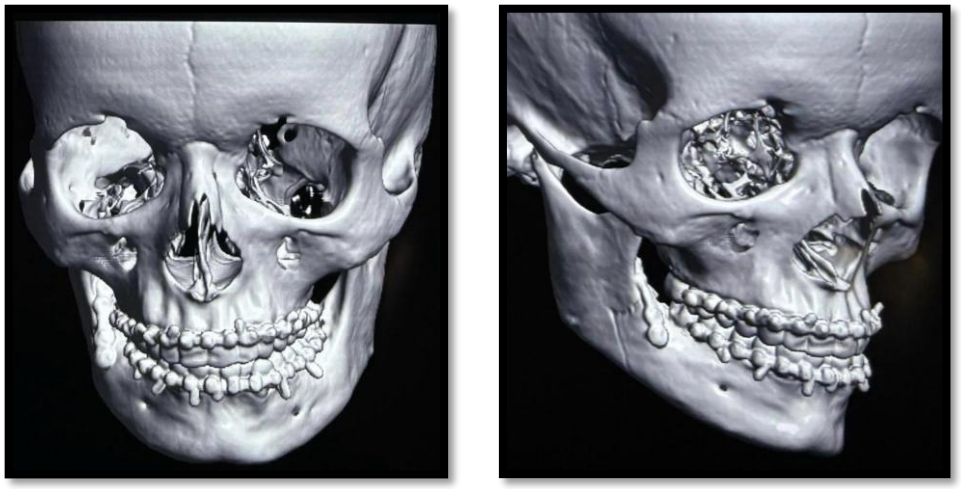
Fig 4 : Group 1 – Intra-operative images (a) Exposure of fracture site (b) Reduction of fracture (c) Fixation of fracture (d) Closure

(a) *(b)* *(c)*

(d) *(e)* *(f)*

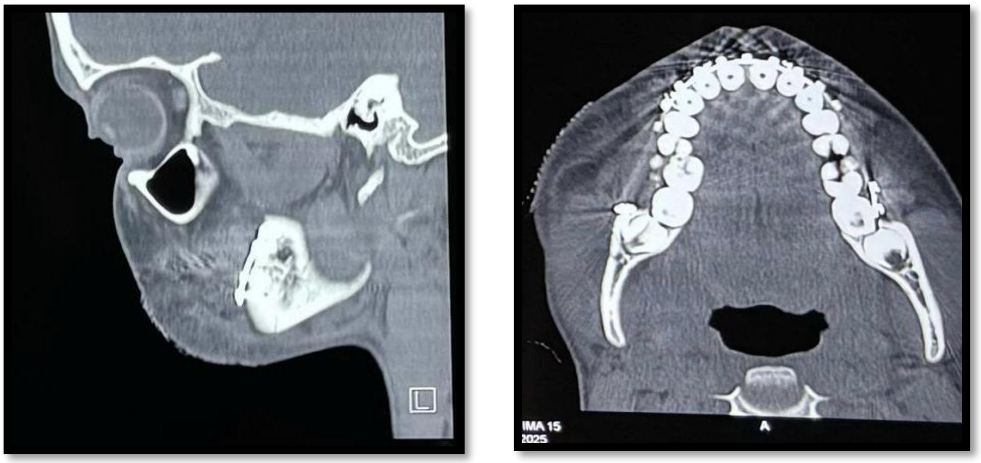
(g)

Fig 5 : Group 1 – Post-operative images (a) Right lateral profile (b) Frontal profile (c) Left lateral profile (d) Right lateral occlusion (e) Frontal occlusion (f) Left lateral occlusion (g) OPG (arrow depicting healing of right mandibular angle fracture)



(a) *(b)*

(c)



(d) *(e)*

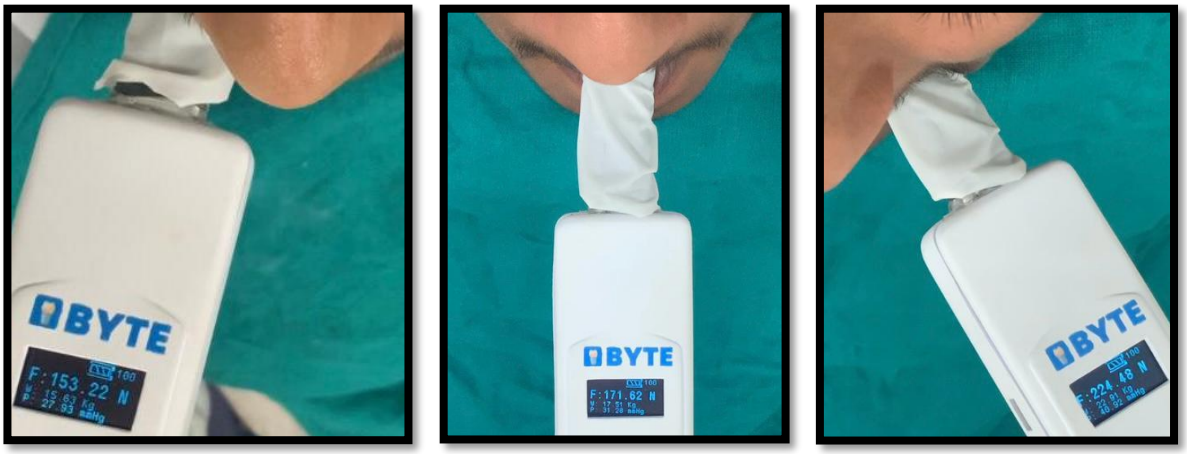
Fig 6 : Group 1 – Post-operative radiographs (a) CT face with 3D reconstruction (frontal view) (b) CT face with 3D reconstruction (lateral view) (c) CT coronal section (d) CT sagittal section (e) CT axial section

(a) *(b)* *(c)*

(d) *(e)* *(f)*

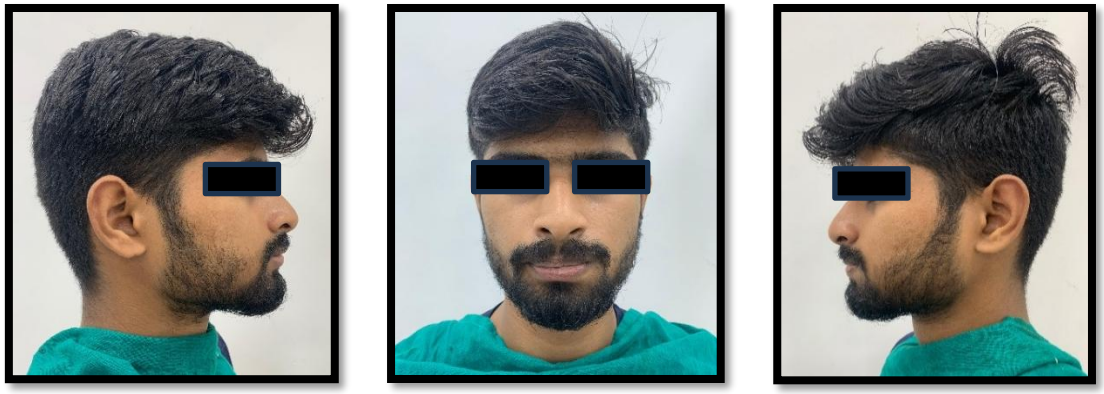
Fig 7 : Group 1 – Post-operative bite force measurements (a) Right molar region (Post-op : 1st week) (b) Incisor region (Post-op : 1st week) (c) Left molar region (Post-op : 1st week) (d) Right molar region (Post-op : 3rd week) (e) Incisor region (Post-op : 3rd week) (f) Left molar region (Post-op : 3rd week)

(a) *(b)* *(c)*



(d) *(e)* *(f)*

Fig 8 : Group 1 – Post-operative bite force measurements (a) Right molar region (Post-op : 6th week) (b) Incisor region (Post-op : 6th week) (c) Left molar region (Post-op : 6th week) (d) Right molar region (Post-op : 9th week) (e) Incisor region (Post-op : 9th week) (f) Left molar region (Post-op : 9th week)



(a) *(b)* *(c)*

(d) *(e)* *(f)*

(g)

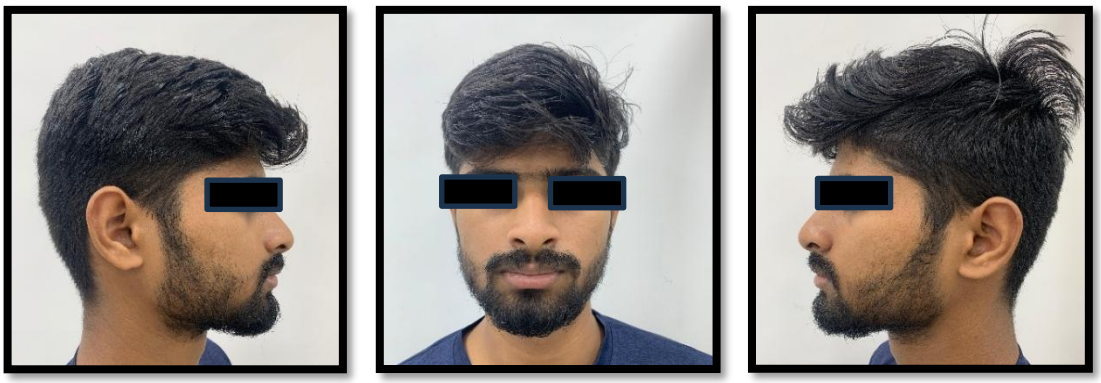
Fig 9 : Group 2 – Pre-operative images (a) Right lateral profile (b) Frontal profile (c) Left lateral profile (d) Right lateral occlusion (e) Frontal occlusion (f) Left lateral occlusion (g) OPG (arrow depicting left mandibular angle fracture)

(a)

(b)

(c)

Fig 10 : Group 2 – Intra-operative images (a) Post – IMF frontal occlusion (b) Post - IMF right lateral occlusion (c) Post - IMF left lateral occlusion



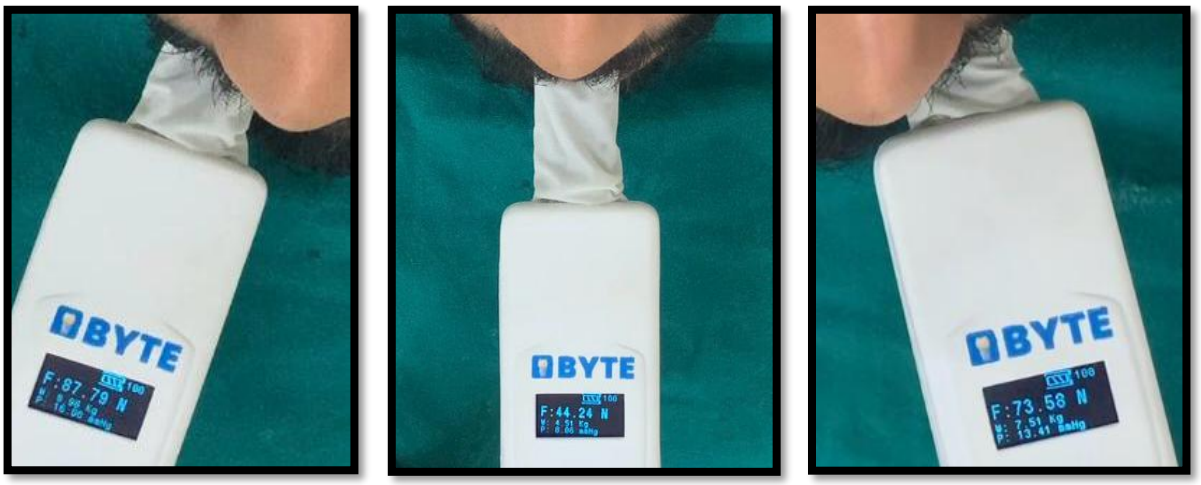
(a) *(b)* *(c)*

(d) *(e)* *(f)*

(g)

Fig 11 : Group 2 – Post-operative images (a) Right lateral profile (b) Frontal profile (c) Left lateral profile (d) Right lateral occlusion (e) Frontal occlusion (f) Left lateral occlusion (g) OPG (arrow depicting healing of left mandibular angle fracture)

(a) *(b)* *(c)*



(d) *(e)* *(f)*

Fig 12 : Group 2 – Post-operative bite force measurements (a) Right molar region (Post-op : 1st week) (b) Incisor region (Post-op : 1st week) (c) Left molar region (Post-op : 1st week) (d) Right molar region (Post-op : 3rd week) (e) Incisor region (Post-op : 3rd week) (f) Left molar region (Post-op : 3rd week)

(a) *(b)* *(c)*

(d) *(e)* *(f)*

Fig 13 : Group 2 – Post-operative bite force measurements (a) Right molar region (Post-op : 6th week) (b) Incisor region (Post-op : 6th week) (c) Left molar region (Post-op : 6th week) (d) Right molar region (Post-op : 9th week) (e) Incisor region (Post-op : 9th week) (f) Left molar region (Post-op : 9th week)

RESULTS

Study Groups	Male	Female	Mean Age
Group 1	100%	0%	30 years
Group 2	83.3%	16.7%	24.20 years

Table 1 : Age and Gender distribution included in the study

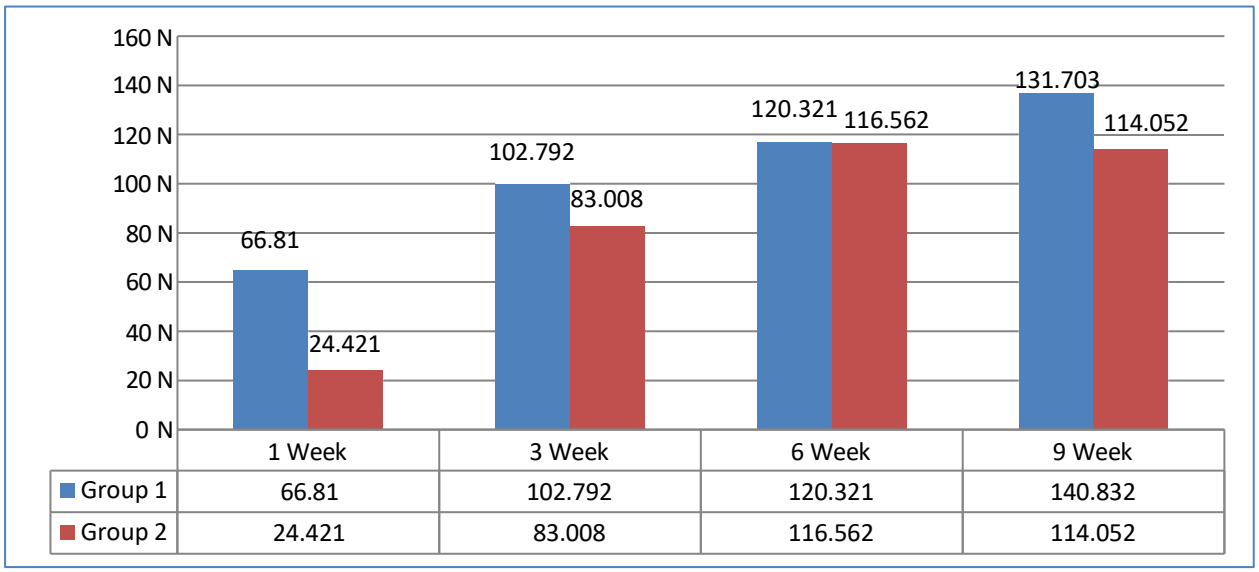
The age and gender distribution of the study subjects showed distinct characteristics between the two groups. In Group 1, which underwent open reduction under general or local anesthesia (GA/LA), all participants were male, with a mean age of 30 years. In contrast, Group 2, which received closed reduction under local anesthesia (LA), had a predominantly male population (83.3%), but also included a smaller proportion of females (16.7%). The mean age of Group 2 participants was notably younger, at 24.2 years (Table 1).

		Mean	Std. Dev	Std. Error	P value	Significance
1st Week	Group 1	66.810	39.858	17.825	0.024	Significant
	Group 2	24.421	11.550	4.715		
3rd Week	Group 1	102.792	60.334	26.982	0.021	Significant
	Group 2	83.008	30.097	12.287		
6th Week	Group 1	120.321	64.455	28.825	0.881	Non-Significant
	Group 2	116.562	13.785	5.628		
9th Week	Group 1	131.703	47.111	21.068	0.297	Non-Significant
	Group 2	114.052	22.960	9.373		

Table 2 : Comparison of mean Post-operative Bite force values between Group 1 and Group 2 in incisor region

The results of the intergroup comparison of postoperative mean bite force values in the incisor region between Group 1 (open reduction under GA/LA) and Group 2 (closed reduction under LA) at different time intervals showed varying outcomes. At the 1st postoperative week interval, Group 1 demonstrated significantly higher mean bite force values (66.81) compared to Group 2 (24.42), with a p-value of 0.024, indicating a statistically significant difference. At 3rd postoperative week also the bite force was significantly higher in the Group 1 as compared to Group 2 (Table 2).

This suggests that, at an early stage of recovery, the open reduction method might provide better initial functional recovery in terms of bite force. However, at the 6th postoperative week interval, no significant differences were observed between the two groups, but at 9th postoperative week again the bite force was significantly higher in the Group 1 as compared to Group 2 . The p-values for these time points were 0.881, and 0.297, respectively, showing that by later stages of healing, Group 1 yielded higher bite force values as compared to Group 2 (Graph 1).



	1 Week	3 Week	6 Week	9 Week
Group 1	66.81	102.792	120.321	140.832
Group 2	24.421	83.008	116.562	114.052

Graph 1: Comparison of mean Post-operative Bite force values between Group 1 and Group 2 in incisor region

	Mean	Std. Dev.	Std. Error
Group 1	131.703	17.235	21.068
Group 2	114.052	22.960	9.373
Control Group	140.832	47.111	10.356

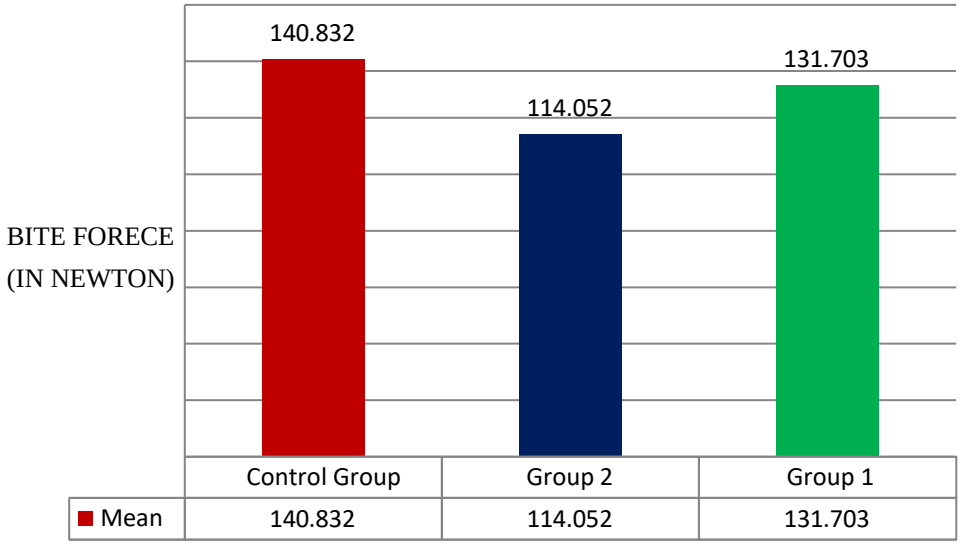
Table 3 : Comparison of Post-operative mean Bite force values of Group 1 and Group 2 in incisor region with the Control Group

	Mean Difference	P value	Significance
Control vs Group 1	9.129	0.547	Non-Significant
Control vs Group 2	26.78	0.043	Significant

Table 4 : P-value and significance of Post-operative mean Bite force values of Group 1 and Group 2 in incisor region with the Control Group

The intergroup comparison of post-operative mean bite force values in the incisor region demonstrated variations among the Control Group and Group 1, Group 2. Control Group exhibited the highest mean bite force at 140.832 ± 47.111 N, followed by Group 1 at 131.703 ± 17.235 N, while Group 2 recorded the lowest value at 114.052 ± 22.960 N (Table 3, Graph 2).

Statistical analysis revealed that the difference between Group 1 and the Control Group (9.129 N, P = 0.547) was not significant, suggesting comparable bite force levels between these groups. However, the difference between Group 2 and the Control Group (26.78 N, P = 0.043) was statistically significant, indicating a notable reduction in bite force within Group 2 (Table 4). This suggests that individuals in Group 2 had a compromised bite force compared to healthy controls but individuals in Group 1, attained bite force values close to healthy control after 9^{th} post-op week.

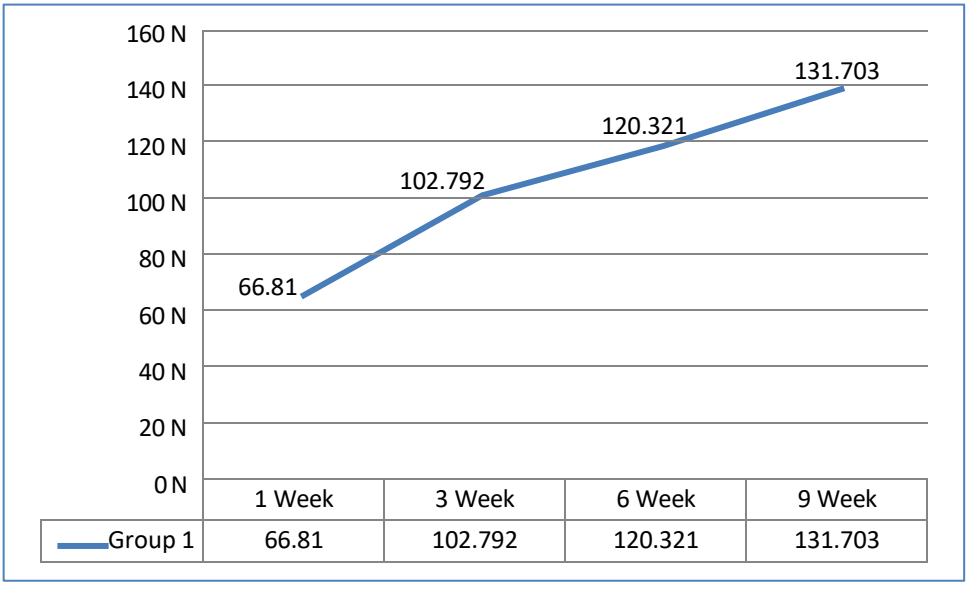


Graph 2: Comparison of Post-operative mean Bite force values of Group 1 and Group 2 in incisor region with the Control Group

Study Group	Post-op	Mean	Std. Dev.	Std. Error	P value	Significance
Group 1	1 Week	66.810	39.858	17.825	0.001	Significant
	3 Week	102.792	60.334	26.982		
Group 1	3 Week	102.792	60.334	26.982	0.001	Significant
	6 Week	120.321	64.455	28.825		
Group 1	6 Week	120.321	64.455	28.825	0.001	Significant
	9 Week	140.832	47.111	21.068		
Group 1	1 Week	66.810	39.858	17.825	0.001	Significant
	9 Week	131.703	47.111	21.068		

Table 5 : Comparison of Post-operative mean Bite force values between different time intervals in Group 1 at incisor region

The intragroup comparison of postoperative mean bite force values within Group 1 (open reduction under GA/LA) at different time intervals in incisor region revealed significant improvements over time. At the 1st post-operative week interval, the mean bite force was 66.81, with a standard deviation of 39.86 and a standard error of 17.83. The comparison between the 1st postoperative week and 3rd postoperative week intervals showed a significant increase in bite force ($p = 0.001$), with the 3rd postoperative week value reaching 102.79. Similarly, there was a significant increase between the 3rd postoperative week and 6th postoperative week intervals ($p = 0.001$), with the 6th postoperative week bite force averaging 120.32. Furthermore, the comparison between the 6th postoperative week and 9th postoperative week intervals also showed a significant increase in bite force ($p = 0.001$), with the 9th postoperative week value reaching 131.703 (Table 5). The statistical significance across all time intervals indicated a continuous improvement in bite force within Group 1 over the course of the study, reflecting the effectiveness of the open reduction method in enhancing bite force recovery at each follow-up point (Graph 3).



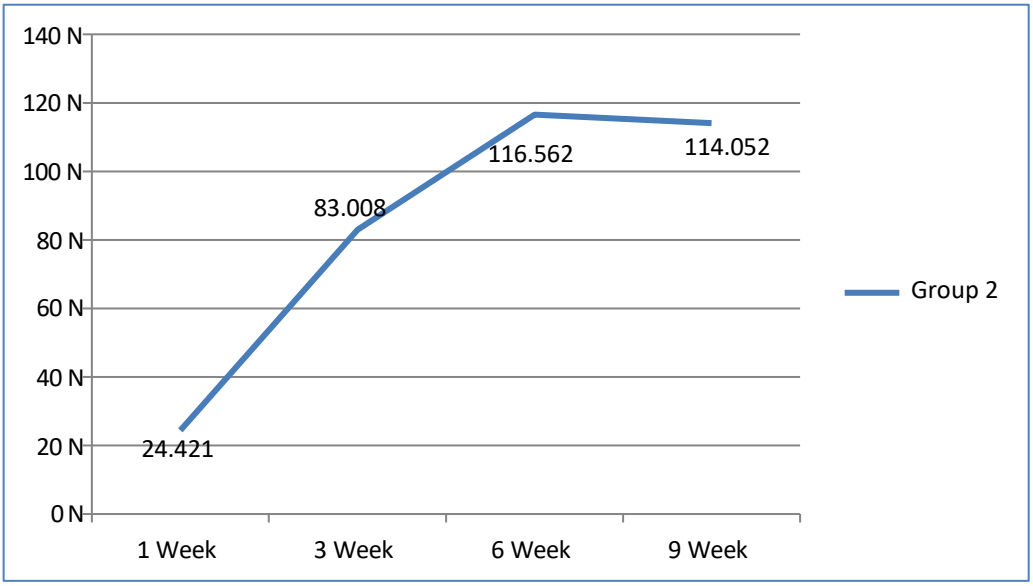
Graph 3: Comparison of Post-operative mean Bite force values between different time intervals in Group 1 at incisor region

Study Group	Post-op	Mean	Std. Dev.	Std. Error	P value	Significance
Group 2	1 Week	24.421	11.550	4.715	0.001	Significant
	3 Week	83.008	30.097	12.287		
Group 2	3 Week	83.008	30.097	12.287	0.001	Significant
	6 Week	116.562	13.785	5.628		
Group 2	6 Week	116.562	13.785	5.628	0.982	Non-Significant
	9 Week	114.052	22.960	9.373		
Group 2	1 Week	24.421	11.550	4.715	0.001	Significant
	9 Week	114.052	22.960	9.373		

Table 6: Comparison of Post-operative mean Bite force values between different time intervals in Group 2 at incisor region

The intragroup comparison of postoperative mean bite force values within Group 2 (closed reduction under LA) across different time intervals at incisor region shows significant improvements in bite force during the early weeks, but no significant change in the later weeks. At the 1st postoperative week, the mean bite force was 24.42, with a standard deviation of 11.55 and a standard error of 4.72. The comparison between the 1st and 3rd postoperative week showed a significant increase in bite force ($p = 0.001$), with the 3rd postoperative week value rising to 83.01. However, between the 3rd and 6th postoperative week, the increase in bite force was not significant ($p = 0.982$), with the 6-week value reaching 116.56. Similarly, there was no significant difference between the 6th postoperative week and 9th postoperative week, as the 9th postoperative week, mean bite force was 114.05 (Table 6). In summary, while there were significant improvements in bite force from 1st to 3rd postoperative week, and from 3rd and 6th postoperative week, the data showed no further significant change after the 6th postoperative week (Graph 4).

This suggests that the bite force in Group 2 stabilized after 6 weeks, indicating that the closed reduction method under LA effectively restores bite force initially, but the improvement may plateau after a certain point.



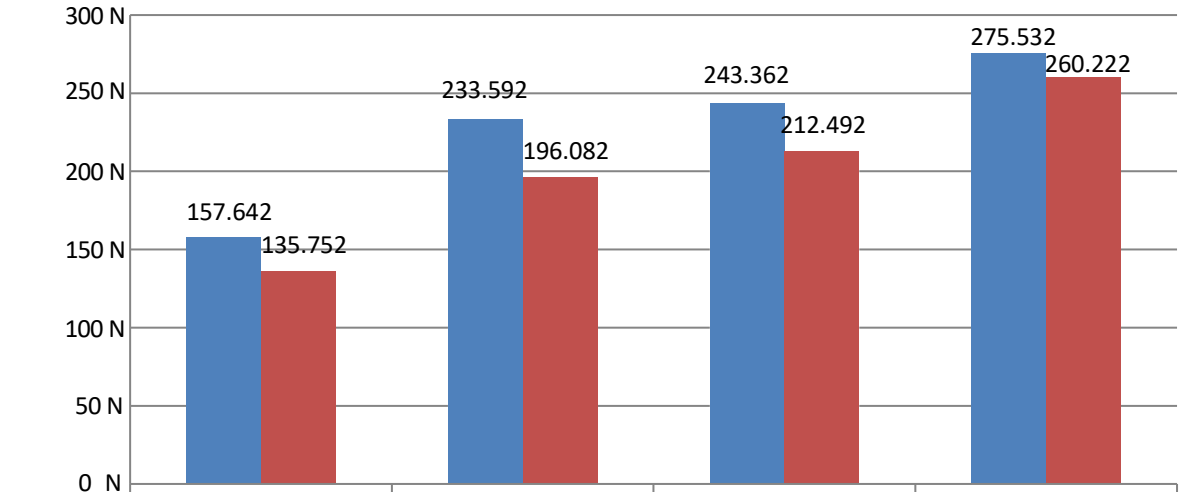
Graph 4: Comparison of Post-operative mean Bite force values between different time intervals in Group 2 at incisor region

Post-op	Study Group	Mean	Std Dev	Std Erro	P value	Significance
1 Week	Group 1	157.642	27.890	10.361	0.001	Significant
	Group 2	135.752	29.086	10.039		
3 Week	Group 1	233.592	27.386	11.592	0.001	Significant
	Group 2	196.082	27.972	14.870		
6 Week	Group 1	243.362	25.828	12.791	0.001	Non-Significant
	Group 2	212.492	20.782	10.599		
9 Week	Group 1	275.532	22.965	15.705	0.739	Non-Significant
	Group 2	260.222	25.045	18.033		

Table 7 : Comparison of mean Post-operative Bite force values between Group 1 and Group 2 in right molar region

The intergroup comparison of postoperative mean bite force values between Group 1 and Group 2 in the right molar region at different time intervals revealed significant differences at early time points, but these differences diminished over time. At 1st postoperative week, Group 1 (157.642 ± 27.890 N) had a significantly higher mean bite force than Group 2 (135.752 ± 29.086 N) (P = 0.001, significant). Similarly, at 3rd postoperative week, Group 1 (233.592 ± 27.386 N) demonstrated a significantly greater bite force than Group 2 (196.082 ± 27.972 N) (P = 0.001, significant). By 6th postoperative week, although Group 1 (243.362 ± 25.828 N) continued to show higher values than Group 2 (212.492 ± 20.782 N), the difference was no longer statistically significant (P = 0.001, non- significant). By 9th postoperative week, Group 1 exhibited higher mean bite force values (275.532 ± 22.965 N in Group 1 vs. 260.222 ± 25.045 N in Group 2), with no significant difference (P = 0.739, non- significant).

These results indicate that while ORIF (Group 1) led to a faster recovery in bite force compared to CR (Group 2), Group 1 ultimately resulted in higher bite force values than Group 2, in the later stages of healing (Table 7, Graph 5).



	1 Week	3 Week	6 Week	9 Week
Group 1	157.642	233.592	243.362	275.532
Group 2	135.752	196.082	212.492	260.222

Graph 5: Comparison of mean Post-operative Bite force values between Group 1 and Group 2 in right molar region

	Mean	Std. Dev.	Std Erro
Group 1	275.532	22.965	15.705
Group 2	260.222	25.045	18.033
Control Group	290.703	24.911	10.356

Table 8 : Comparison of Post-operative mean Bite force values of Group 1 and Group 2 in right molar region with the Control Group

	Mean Difference	P value	Significance
Control vs Group 1	15.3710	0.553	Non-Significant
Control vs Group 2	30.4810	0.032	Significant

Table 9 : P-value and significance of Post-operative mean Bite force values of Group 1 and Group 2 in right molar region with the Control group

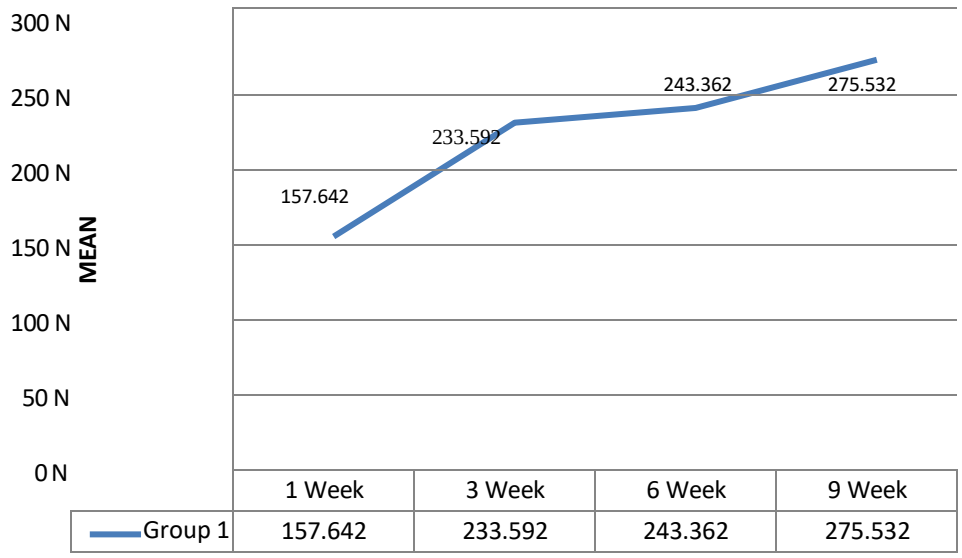
The intergroup comparison of postoperative mean bite force values in the right molar region between Group 1 (ORIF), Group 2 (CR), and the Control Group showed varying levels of statistical significance. The control group had the highest mean bite force (290.703 ± 24.911 N), followed by Group 1 (275.532 ± 22.965 N) and Group 2 (260.222 ± 25.045 N), (Table 8). When comparing Group 1 to the control group, the mean difference was 15.371 N, which was not statistically significant (P = 0.553). However, when comparing Group 2 to the control group, the mean difference was 30.481 N, which was statistically significant (P = 0.032), (Table 9). These findings suggest that while ORIF (Group 1) resulted in bite force values comparable to the control group, CR (Group 2) led to a significantly lower bite force compared to normal values. This indicates that ORIF may allow for better functional recovery of bite force than CR.

Study Group	Post-op	Mean	Std Dev	Std Erro	P value	Significance
Group 1	1 Week	157.642	27.890	10.361	0.001	Significant
	3 Week	233.592	27.386	11.592		
Group 1	3 Week	233.592	27.386	11.592	0.001	Significant
	6 Week	243.362	25.828	12.791		
Group 1	6 Week	243.362	25.828	12.791	0.001	Significant
	9 Week	275.532	22.965	15.705		
Group 1	1 Week	157.642	67.890	30.361	0.001	Significant
	9 Week	275.532	22.965	15.705		

Table 10 : Comparison of Post-operative mean Bite force values between different time intervals in Group 1 at right molar region

The intragroup comparison of postoperative mean bite force values in the right molar region at different time intervals for Group 1 (ORIF) showed a statistically significant increase over time. At 1st postoperative week, the mean bite force was 157.642 ± 27.890 N. By 3rd postoperative week, it significantly increased to 233.592 ± 27.386 N (P = 0.001). A further increase was observed at 6th postoperative week (243.362 ± 25.828 N, P = 0.001), and by 9th postoperative week, the bite force reached 275.532 ± 22.965 N, which was significantly higher than all previous time points (P = 0.001), (Table 10).

These results suggest a steady and significant improvement in bite force overtime in patients treated with ORIF, highlighting its effectiveness in restoring masticatory function. Overall, the results indicate a statistically significant increase in bite force within Group 1 across all time intervals, showing a continuous improvement in bite force following open reduction and internal fixation (ORIF) over the course of the nine postoperative weeks (Graph 6).



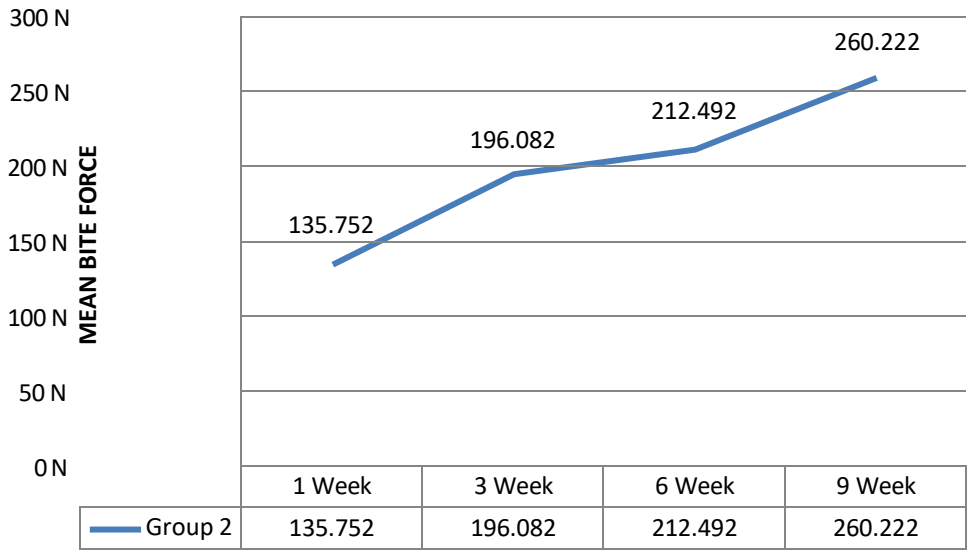
Graph 6: Comparison of Post-operative mean Bite force values between different time intervals in Group 1 at right molar region

Study Group	Post-op	Mean	Std Dev	Std Error	P value	Significance
Group 2	1 Week	135.752	29.086	10.039	0.001	Significant
	3 Week	196.082	27.972	14.870		
Group 2	3 Week	196.082	27.972	14.870	0.001	Significant
	6 Week	212.492	20.782	10.599		
Group 2	6 Week	212.492	20.782	10.599	0.001	Significant
	9 Week	260.222	25.045	18.033		
Group 2	1 Week	135.752	29.086	10.039	0.001	Significant
	9 Week	260.222	25.045	18.033		

Table 11 : Comparison of Post-operative mean Bite force values between different time intervals in Group 2 at right molar region

The intragroup comparison of postoperative mean bite force values in the right molar region at different time intervals for Group 2 (CR) demonstrated a statistically significant increase over time. At 1st postoperative week, the mean bite force was 135.752 ± 29.086 N. By 3rd postoperative week, it significantly increased to 196.082 ± 27.972 N (P = 0.001). A further rise was observed at 6th postoperative week (212.492 ± 20.782 N, P = 0.001), and by 9th postoperative week, the bite force reached 260.222 ± 25.045 N, which was significantly higher than all previous time points (P = 0.001), (Table 11).

These findings indicate a steady and significant improvement in bite force overtime in patients treated with closed reduction (CR), though the progression appears somewhat slower compared to ORIF (Graph 7).



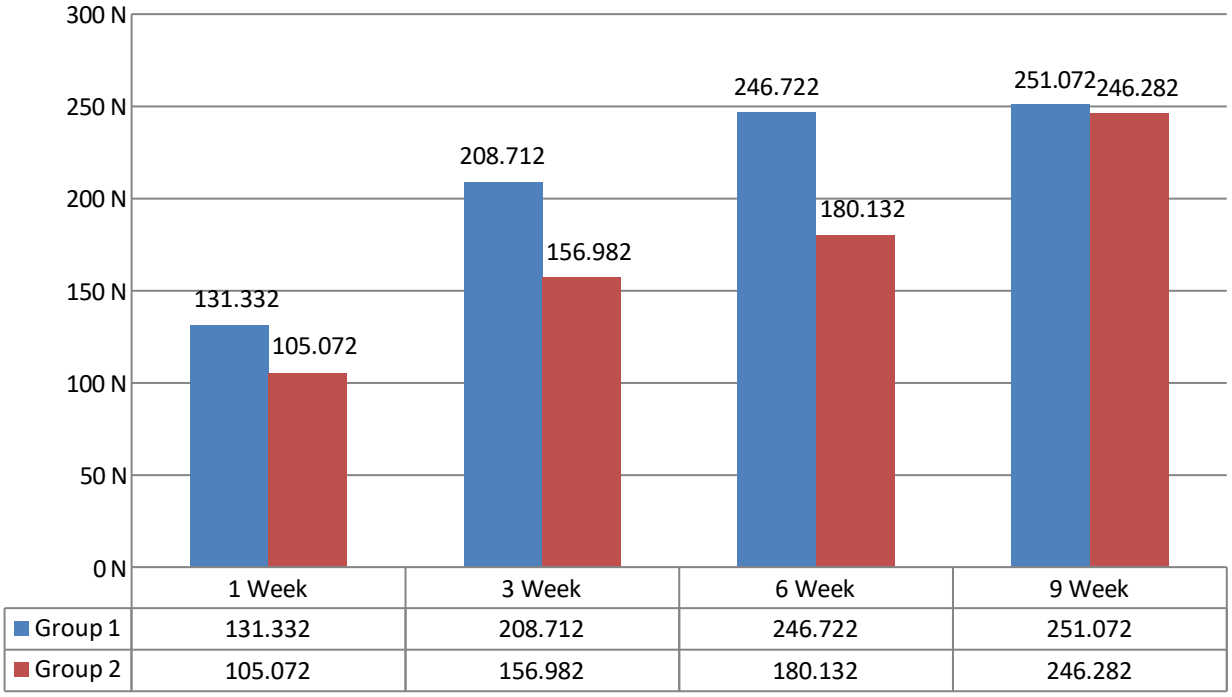
Graph 7: Comparison of Post-operative mean Bite force values between different time intervals in Group 2 at right molar region

Post-op	Study Group	Mean	Std Dev	Std Erro	P value	Significance
1 Week	Group 1	131.332	25.318	14.739	0.039	Significant
	Group 2	105.072	28.840	15.856		
3 Week	Group 1	208.712	23.012	15.724	0.001	Significant
	Group 2	156.982	27.791	15.845		
6 Week	Group 1	246.722	21.047	10.839	0.001	Significant
	Group 2	180.132	25.833	13.913		
9 Week	Group 1	251.072	29.231	16.016	0.901	Non-Significant
	Group 2	246.282	21.442	16.422		

Table 12: Comparison of mean Post-operative Bite force values between Group 1 and Group 2 in left molar region

The intergroup comparison of postoperative mean bite force values in the left molar region between Group 1 (ORIF) and Group 2 (CR) at different time intervals revealed significant differences in the early weeks, but these differences diminished over time. At 1st postoperative week, Group 1 demonstrated a significantly higher bite force (131.332 ± 25.318 N) compared to Group 2 (105.072 ± 28.840 N, P = 0.039). This trend continued till 3rd postoperative week, where Group 1 (208.712 ± 23.012 N) maintained a significantly greater bite force than Group 2 (156.982 ± 27.791 N, P = 0.001). The gap persisted at 6th postoperative week, with Group 1 (246.722 ± 21.047 N) still exhibiting superior values compared to Group 2 (180.132 ± 25.833 N, P = 0.001). However, by 9th postoperative week, the bite force values between the two groups became nearly equal, with Group 1 at 251.072 ± 29.231 N and Group 2 at 246.282 ± 21.442 N, showing no statistically significant difference (P = 0.901), (Table 12).

This suggests that while ORIF initially facilitates a faster recovery of bite force, CR patients eventually catch up, reaching comparable bite force values by the 9th postoperative week (Graph 8).



Graph 8: Comparison of mean Post-operative Bite force values between Group 1 and Group 2 in left molar region

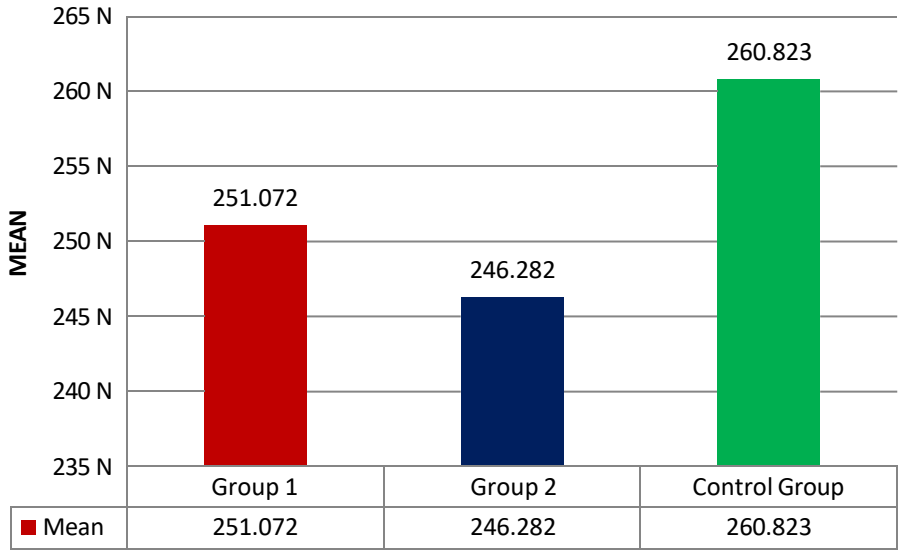
	Mean	Std Dev	Std Error
Group 1	251.072	29.231	16.016
Group 2	246.282	21.442	16.422
Control Group	260.823	29.911	10.356

Table 13: Comparison of Post-operative mean Bite force values of Group 1 and Group 2 in left molar region with the Control Group

	Mean Difference	P value	Significance
Control vs Group 1	9.751	0.123	Non-Significant
Control vs Group 2	14.541	0.047	Significant

Table 14: P-value and significance of Post-operative mean Bite force values of Group 1 and Group 2 in left molar region with the Control Group

The intergroup comparison of postoperative mean bite force values in the left molar region revealed variations between Group 1 (ORIF), Group 2 (CR), and the Control Group. Group 1 exhibited a mean bite force of 251.072 N, while Group 2 demonstrated a slightly lower value of 246.282 N. The control group recorded a higher mean bite force of 260.823 N (Table 13, Graph 9). When comparing Group 1 to the control group, the mean difference was 9.751 N, which was not statistically significant (P = 0.123). This suggests that patients in Group 1 achieved bite force levels comparable to healthy individuals, indicating effective recovery with ORIF treatment. However, Group 2 showed a significantly lower bite force compared to the control group, with a mean difference of 14.541 N (P = 0.047, significant), (Table 14). This finding indicates that patients treated with CR exhibited a slight but notable deficit in bite force recovery, suggesting that ORIF may be more effective in restoring masticatory function to near-normal levels.



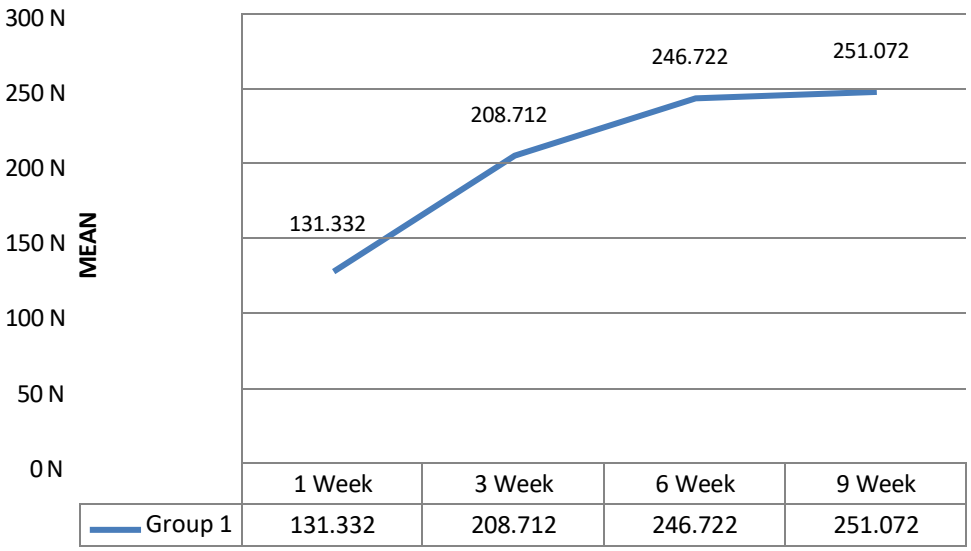
Graph 9: Comparison of Post-operative mean Bite force values of Group 1 and Group 2 in left molar region with the Control Group

Study Group	Post-op	Mean	Std Dev	Std Error	P value	Significance
Group 1	1 Week	131.332	25.318	14.739	0.001	Significant
	3 Week	208.712	23.012	15.724		
Group 1	3 Week	208.712	23.012	15.724	0.001	Significant
	6 Week	246.722	21.047	10.839		
Group 1	6 Week	246.722	21.047	10.839	0.001	Significant
	9 Week	251.072	29.231	16.016		
Group 1	1 Week	131.332	25.318	14.739	0.001	Significant
	9 Week	251.072	29.231	16.016		

Table 15: Comparison of Post-operative mean Bite force values between different time intervals in Group 1 at left molar region

The intragroup comparison of postoperative mean bite force values in the left molar region for Group 1 (ORIF) at different time intervals showed a steady and significant increase overtime (Graph 10). At 1st postoperative week, the mean bite force was 131.332 ± 25.318 N. By 3rd postoperative week, there was a statistically significant improvement (208.712 ± 23.012 N, P = 0.001). This increasing trend continued till 6th postoperative week, reaching 246.722 ± 21.047 N (P = 0.001), and further improved by 9th postoperative week to 251.072 ± 29.231 N (P = 0.001), (Table 15).

The progressive rise in bite force overtime suggests a continuous recovery in masticatory function, with a significant improvement from 1st to 9th postoperative week. The stabilization of values between 6th and 9th postoperative week indicates that most functional recovery occurs within the first 6 weeks postoperatively.

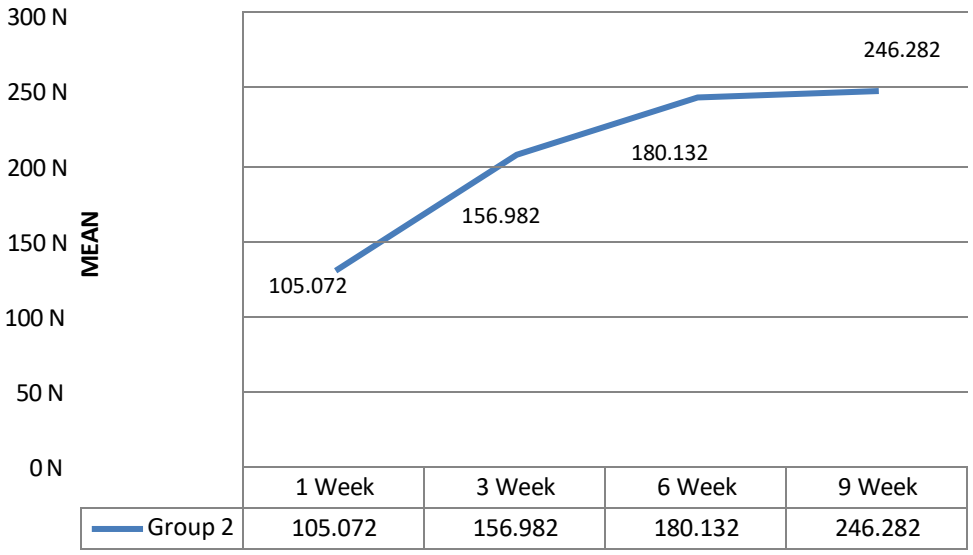


Graph 10: Comparison of Post-operative mean Bite force values between different time intervals in Group 1 at left molar region

Study Group	Post-op	Mean	Std Dev	Std Erro	P value	Significance
Group 2	1 Week	105.072	28.840	15.856	0.001	Significant
	3 Week	156.982	27.791	15.845		
Group 2	3 Week	156.982	27.791	15.845	0.001	Significant
	6 Week	180.132	25.833	13.913		
Group 2	6 Week	180.132	25.833	13.913	0.047	Significant
	9 Week	246.282	21.442	16.422		
Group 2	1 Week	105.072	28.840	15.856	0.001	Significant
	9 Week	246.282	21.442	16.422		

Table 16: Comparison of Post-operative mean Bite force values between different time intervals in Group 2 at left molar region

The intragroup comparison of postoperative mean bite force values in the left molar region for Group 2 (CR) at different time intervals revealed a gradual and statistically significant increase overtime (Graph 11). At 1st postoperative week, the mean bite force was 105.072 ± 28.840 N. By 3rd postoperative week, there was a significant improvement (156.982 ± 27.791 N, P = 0.001). This increasing trend continued till 6th postoperative week, reaching 180.132 ± 25.833 N (P = 0.047, Significant), and further improved by 9th postoperative week to 246.282 ± 21.442 N (P = 0.001), (Table 16). The consistent increase in bite force overtime indicates progressive functional recovery. The improvement from 1st to 9th postoperative week was statistically significant, with a notable acceleration between 3rd and 9th postoperative week. However, compared to Group 1 (ORIF), the recovery in Group 2 (CR) was slightly delayed, suggesting a more gradual restoration of masticatory function in conservative management.



Graph 11: Comparison of Post-operative mean Bite force values between different time intervals in Group 2 at left molar region

DISCUSSION

Knowledge of anatomy of mandible and the muscular forces applied to it is the key to proper reduction of mandibular fracture. The goal in reduction is to restore premorbid occlusion, allowing patients to resume masticatory functions.

The mandible is the largest, heaviest and strongest bone of the face. It acts like a cantilever beam that interfaces the skull base. This relationship creates a parabola or ring like structure prone to certain fracture patterns. The mandible has been compared to an archery bow, which is strongest at its center and weakest at its ends, where it often breaks. The body is thick, has a rounded lower body & carries alveolar process on its upper border. It extends backward from the chin at the midline symphysis to the anterior limit of ramus. The ramus is thin quadrilateral plate. It reaches upward to end in two processes, the anterior muscular coronoid process & the posterior articular condylar process. The anterior border of the ramus ends along the body lateral to the alveolar process as a blunt ridge, the oblique ridge running downward & forward to disappear at about the level of the 1st molar.[1]

The mandible of adult is made of compact outer & inner cortical plates with central portion of spongiosa. Trabeculae are distributed along lines of maximum stress in spongiosa. Out of the two cortical lates, buccal cortical plate is thicker than lingual cortical plate & thickest in symphysis region. Buccal cortex is reinforced by external oblique ridge in the body of mandible & the later runs downwards from the coronoid process, thus providing a good anchorage to the osteosynthesis screw by virtue of its compact bone separated by various portion of cancellous bone. There is change in direction between body & ramus that acts as the area of stress concentration. The energy required to fracture a mandible is approximately 44.6 to 74.4 Kg/M.[3]

The mandibular canal runs from the lingual of the mandible to the mental foramen on a concave course directed upwards & forwards. The blood supply of the mandible is via the inferior alveolar artery that runs in the inferior alveolar canal. Additionally, blood supply from the surrounding periosteum plays an important role in healing, especially in the elderly and in injuries that include the canal. The nerve supply of the mandible is via mandibular nerve. The mental nerve runs with the inferior alveolar artery and injury to the canal produces numbness of the ipsilateral lip and chin.[11]

The muscles, which originate from the lateral aspect of mandible, have no significant effect on the displacement (except masseter) but the muscles attached to inner aspect exert a centripetal forces so the fracture fragments tend to collapse posteriorly & medially.

The masseter, temporalis & medial pterygoid pull the fracture segments medially & upwards while the geniohyoid, digastric & mylohyoid tend to displace the fracture segments medially, posteriorly & inferiorly. During functional movements compression forces develop at lower border and tension forces develop at upper border of the mandible. The result of these forces causes distraction at the alveolar crest region. The masseter, medial pterygoid, and temporalis are muscles of mastication that act to produce motion and support mandible. The directional pull of these muscles determine stability of certain fracture patterns. The masseter and temporalis muscle exert upward pull on the angle of the mandible, which will distract horizontally unfavourable fractures from each other in a vertical dimension. The medial and lateral pterygoid muscles exert medial pull on ramus of the mandible and will distract vertically unfavourable fractures medially.[17]

Symphysis region is formed by the bony union of two halves in the centre at first year of birth. Symphysis fracture is seen at this line of weakness. Parasymphysis region lateral to the mental protuberance is a naturally weak area susceptible to fracture because of presence of long canine root, change in trajectories of force and incisive fossa. The body of the mandible is considerably thicker than the ramus and the junction of these two portions constitutes a line of structural weakness.[3]

Angle fractures are commonly seen due to curvature of trajectories in this region. The presence of third molars also makes the area more vulnerable to the fracture. The slender neck of the mandibular condyle renders it particularly liable to fracture as a result of direct violence to the chin. This anatomical weakness acts as a safety mechanism and fracture at the neck of the condyle prevents injury to the middle cranial fossa.[4]

The mandible is suspended bilaterally by a system of muscle, tendon & ligament that enable it to move like a two arms lever around an imaginary transverse axis. This axis is approximately in the area of the mandibular foramen, so that the inferior alveolar nerve enters the mandibular canal at the least mobile & most protected site. This point marks one end of the "Line of Zero Force" along which the forces are largely neutralized by virtue of unequal stress distribution in the bone.[3]

Champy et al. were developing the concept of adaptive osteosynthesis. Champy advocated transoral placement of small, thin, malleable stainless steel miniplates with mono-cortical screws along an ideal osteosynthesis line of mandible. Champy believed that compression plates were unnecessary due to masticatory forces that produce a natural strain of compression along the inferior border. Masticatory muscle function normally produces tension at the upper border of the mandible with compressive forces at the lower border. In addition, torsional forces

are produced in the area anterior to the canines. In a series of experiments, champy was able to define ideal lines of osteosynthesis. Mono-cortical "tension banding" osteosynthesis results in neutralization of distracting and torsional forces exerted on the fracture during physiologic stress, while the normal compressive forces at the basilar aspect of the mandible are restored.

Posterior to the mental foramen, a single plate is placed below the dental roots and above the inferior alveolar nerve. Anterior to mental foramina two plates are necessary to neutralize the torsional forces. The advantage of mono-cortical miniplates is that they can be applied nearly anywhere in the mandible via an intraoral approach.[8]

Probable reason for a decrease in bite force after treatment of fractures of the mandibular angle is traumatic and surgical damage to the masseter and temporalis muscles. Placing fixation hardware from an intraoral approach necessitates the masseter muscle and a portion of the insertion of the temporalis muscle being stripped from their attachments to the lateral border of the mandible. All of these mechanisms are probably responsible for a reduction in bite force after injury and open treatment.[4]

In a retrospective study on 1,521 patients by Bochlogyros PN (1985) over a period of 20 years, in which they found that the main etiological factor in their study was road traffic accident.[1] In the present study, RTA was to be the main etiological factor was road traffic accidents (RTA).

This study compared the recovery period of maximum bite force between two widely used treatment modalities - open reduction and internal fixation (ORIF) and closed reduction (CR), through a prospective clinical evaluation over a 9-week period.

The age and gender distribution of the study subjects showed distinct characteristics between the two groups. In Group 1 (open reduction under general or local anesthesia), all participants were male, with a mean age of 30 years. Group 2 (closed reduction under local anesthesia) had a predominantly male population (83.3%), with a smaller proportion of female participants (16.7%). The mean age of Group 2 participants was notably younger, at 24.2 years. The majority of the patients in this study were males which was similar to the study conducted by Wook-Jae Yoon et al in 2014. In their study 56 males (90.3%) and 6 females (9.7%) were present.[34]

Koc et al. stated that the normal aging process caused changes in masticatory muscle force, which stayed fairly constant from about 20 years to 50 years of age and then declined.[5]

Bite force serves as a quantifiable indicator of functional recovery following mandibular fracture intervention.

In this study, at the incisor region, Group 1 recorded a significantly higher postoperative mean bite force than Group 2 at 1st and 3rd week ($p = 0.024$ and 0.021, respectively), which revealed

early function in patients treated with ORIF at incisor region. In the incisor region, the postoperative mean bite force in Group 1 increased from 66.810 N to 131.703 N from post-op week 1 to post-op week 9, respectively. For Group 2, values increased from 24.421 N to 114.052 N over the same post-op period. Group 1 continued to show higher values in the incisor region at 1st, 3rd, 6th and 9th post-op weeks in comparision with Group 2. This study suggested more consistent recovery trends in post-operative bite forces with ORIF (Group 1) at incisor region, when compared to CR (Group 2). Findings of this study were similar to the study conducted by Kshirsagar R et al, which concluded that incisor bite forces were reduced significantly in the 1st and 2nd post-operative weeks of parasymphyseal fracture treated by ORIF and regained significantly till 4th to 6th postoperative weeks. Bite forces in molar region took 6 to 12 postoperative weeks to regain maximum bite force, when compared with the volunteer group.[6]

In this study, similar trends were observed in the right and left molar regions. Group 1 had statistically higher postoperative bite forces at 1st and 3rd post-op weeks in both regions (right and left molar).

In the right molar region, the postoperative mean bite force in Group 1 increased from 157.64 N to 275.53 N from post-op week 1 to post-op week 9. For Group 2, values increased from 135.75 N to 260.22 N over the same postoperative period, showing functional improvement, but delayed compared to ORIF.

In the left molar region, the postoperative mean bite force in Group 1 increased from 131.332 N to 251.072 N from post-op week 1 to post-op week 9. For Group 2, values increased from 105.072 N to 246.282 N over the same postoperative period.

In this study, patients treated for mandibular fractures with ORIF (Group 1) demonstrated a significantly faster and greater recovery in bite force across all measured regions - incisor, right molar, and left molar, particularly in the early post-operative weeks (1st and 3rd) when compared to those managed with CR (Group 2). We found that our study findings, on the evaluation of bite forces after treatment of mandibular angle fractures with miniplates osteosynthesis, were comparable to the studies by Gerlach KL and Schwarz A (2002), they evaluated bite forces after treatment of mandibular angle fractures with miniplates osteosynthesis. They found in comparison with control group, patients showed a significant reduction of bite force in initial post-op days (1st, 2nd, and 3rd), but slightly increased bite forces from 1st to 3rd postoperative week were noted. While after 4th postoperative week no significant reduction was observed, but after 5th postoperative week significant drop in maximum bite force observed followed by an increase at 6th week.[2]

Notably, in this study, by post-op week 9, the differences in bite forces between both study groups, across measured regions - incisor, right molar, and left molar, were no longer statistically significant. The suggested that CR (Group 2) ultimately achieved similar outcomes but the initial recovery period of post-op bite force (1st and 3rd post-op week) was observed to be significantly faster in ORIF (Group 1). However, our study findings were similar to Pal K et al. Their study revealed, that three months post-operatively, open reduction and internal fixation (n = 30) shows significantly better results i.e. higher bite force values than the closed reduction (n = 30) of mandibular fracture across incisor, right and left molar regions and also ORIF group, approached control group bite force values by 12th post-op week, while CR group remained significantly lower in values.[12]

In this study, we found that in the control group (age range: 21 to 60 years, n = 12) the mean bite force values at incisor region (140.703 N), right molar region (290.703 N) and left molar region (260.823 N) were similar to findings of study by Singh S et al (2011). In their study they revealed that the mean values for maximal bite forces in healthy individuals varied from 216 N to 740 N at molar region and upto 150 N at incisor region using new novel bite force recorder (gnathodynamometer).

This study also revealed that the post-operative bite forces of patients included in Group 1, closely approached (but not exceeded) the control group bite force values by 9th post-op week, while those of Group 2 remained significantly lower ($p = 0.043$ vs. controls), indicating a lingering functional deficit with Group 2.

In a study by Ellis III E et al (2000), which suggested that patients treated by closed techniques had a significantly greater percentage of malocclusion compared with patients treated by open reduction, in spite of the fact that the initial displacement of the fractures was greater in patients treated by open reduction.[18] However, in our study, we did not evaluated secondary outcome variables such as malocclusion which could be consider as a limitation of the study.

CONCLUSION

The treatment of mandibular fractures requires adequate fracture reduction and stabilization through a closed or open technique. Success relies on the restoration of normal dental occlusion and bony union. The treatment chosen may differ due to factors such as cost of treatment, patient's affordability, surgeon's skill, and patients willingness to avail the treatment advised; all of which may vary from one country to another. The evaluations of bite force have been proven to be constructive and thus widely utilized in dentistry, with the aim of determining muscular activity and jaw movements during the chewing process during fracture healing. These measurements are also valuable in terms of providing reference values for studies on the biomechanics of jaw, its articulation and mechanism of mastication. In additional bite force has been considered important in the diagnosis of the disturbances of the stomatognathic system.

Our study on period of recovery of maximum bite force following open and closed technique for management of mandibular fracture, suggested open reduction and internal fixation to be a superior and effective method with quick recovery of maximum bite force, compared to the closed reduction.

In our study, the bite forces of patients treated using open reduction showed better improvement at the end of 9^{th} post-operative week. This study suggests, future studies with larger sample size involving longer duration of follow up period are required to come to a definitive conclusion and to obtain more meaningful results.

With the results of this study suggested that the patients treated for mandibular fractures with ORIF (Group 1) demonstrated a significantly faster and greater recovery in bite force across all measured regions - incisor, right molar, and left molar, particularly in the early post-operative weeks (1^{st} and 3^{rd}) when compared to those managed with CR (Group 2).

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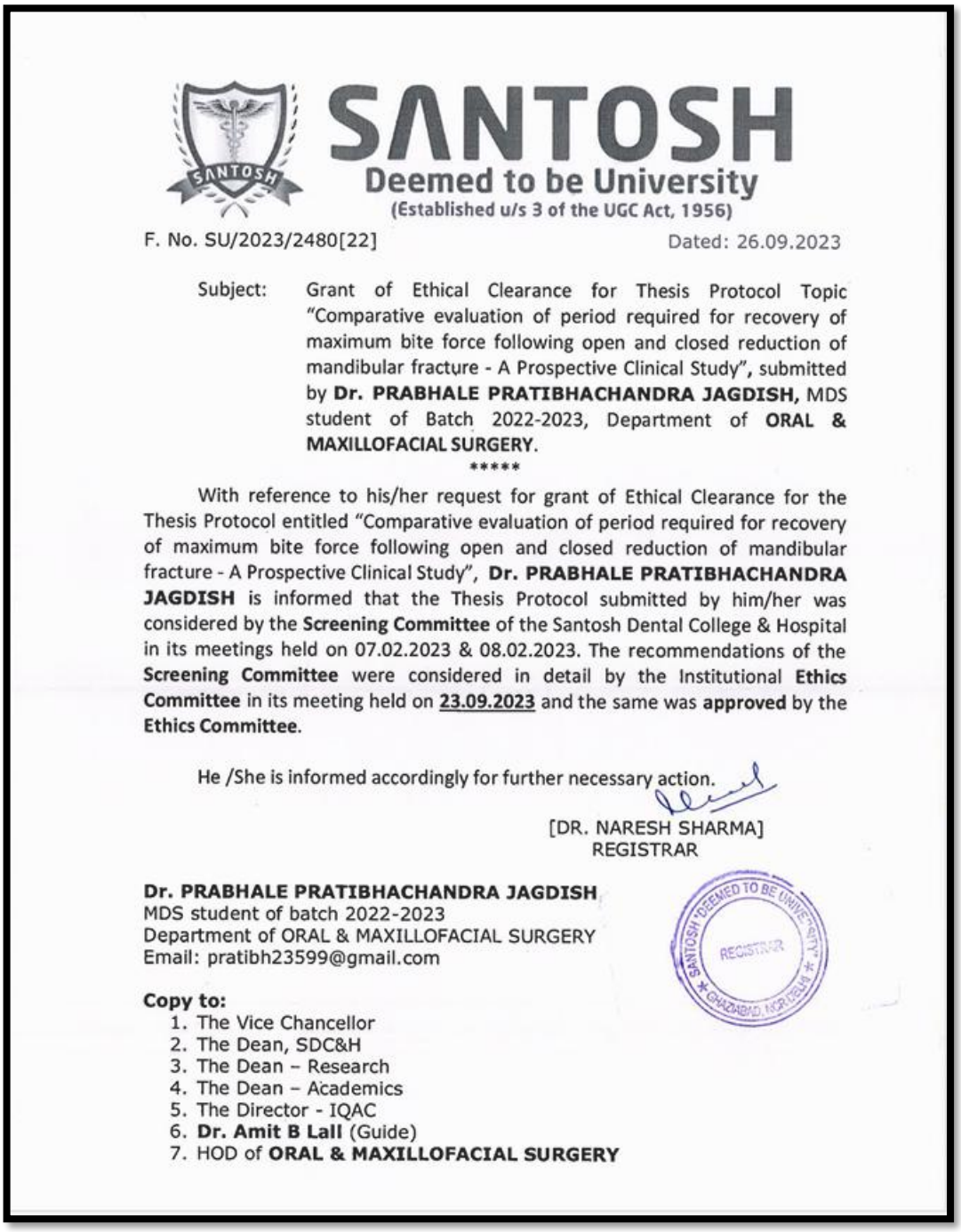
ANNEXURE – 1

ETHICAL COMMITTEE CLEARANCE FORM



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F. No. SU/2023/2480[22] Dated: 26.09.2023

Subject: Grant of Ethical Clearance for Thesis Protocol Topic "Comparative evaluation of period required for recovery of maximum bite force following open and closed reduction of mandibular fracture - A Prospective Clinical Study", submitted by **Dr. PRABHALE PRATIBHACHANDRA JAGDISH,** MDS student of Batch 2022-2023, Department of **ORAL & MAXILLOFACIAL SURGERY.**

*****

With reference to his/her request for grant of Ethical Clearance for the Thesis Protocol entitled "Comparative evaluation of period required for recovery of maximum bite force following open and closed reduction of mandibular fracture - A Prospective Clinical Study", **Dr. PRABHALE PRATIBHACHANDRA JAGDISH** is informed that the Thesis Protocol submitted by him/her was considered by the **Screening Committee** of the Santosh Dental College & Hospital in its meetings held on 07.02.2023 & 08.02.2023. The recommendations of the **Screening Committee** were considered in detail by the Institutional **Ethics Committee** in its meeting held on **23.09.2023** and the same was **approved** by the **Ethics Committee**.

He /She is informed accordingly for further necessary action.

[DR. NARESH SHARMA]
REGISTRAR

Dr. PRABHALE PRATIBHACHANDRA JAGDISH
MDS student of batch 2022-2023
Department of ORAL & MAXILLOFACIAL SURGERY
Email: pratibh23599@gmail.com

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6. **Dr. Amit B Lall** (Guide)
7. HOD of **ORAL & MAXILLOFACIAL SURGERY**

ANNEXURE – 2

ANTI PLAGIARISM REPORT

DR. PRABHALE PRATIBHCHANDRA JAGDISH

COMPARATIVE EVALUATION OF PERIOD REQUIRED FOR RECOVERY OF MAXIMUM BITE FORCE FOLLOWING OPEN AN...

Santosh University, Ghaziabad

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ANNEXURE – 3

PATIENT PROFORMA

NAME:

AGE/SEX:

OPD NO: OCCUPATION: ADDRESS:

CHIEF COMPLAINT:

HISTORY OF PRESENT ILLNESS:

PAST MEDICAL HISTORY:

PAST DENTAL HISTORY

FAMILY HISTORY:

HABITS:

GENERAL PHYSICAL EXAMINATION:

Glasgow Coma Scale:

Built:

Gait:

Height:

Weight:

Vitals:

BP:

Pulse:

Respiratory rate:

Temperature:

Spo_2 :

Pallor:

Icterus:

Cyanosis:

Clubbing:

Lymphadenopathy:

Edema:

Associated injuries:

LOCAL EXAMINATION:

Extraoral examination:

Inspection:

Facial symmetry:

Upper third of face:

Middle third of face:

Lower third of face:

TMJ:

Palpation:

Upper third of face:

Middle third of face:

Lower third of face:

TMJ:

Intraoral examination:

Inspection:

Dentition:

Occlusion:

Interincisal mouth opening:

Range of motion:

Lateral movement-

Protrusive movement-

Retrusive movement-

Intraoral soft tisue injury:

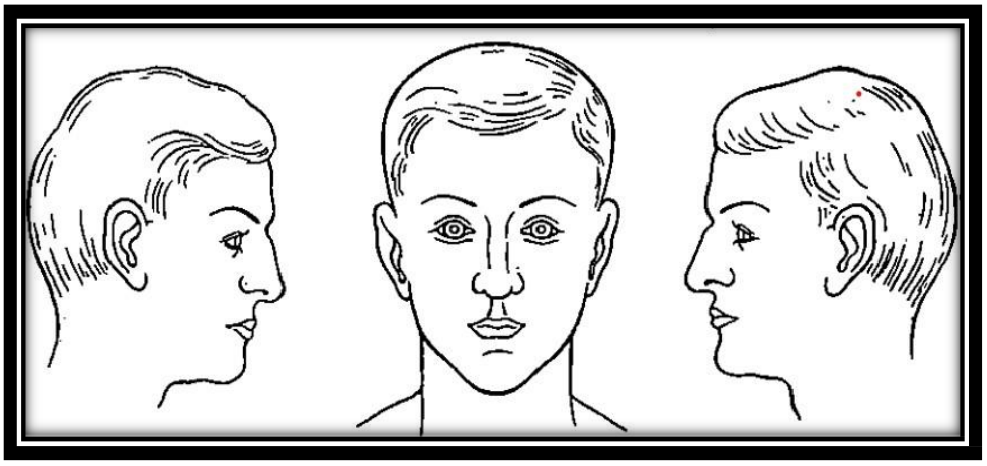
PROVISIONAL DIAGNOSIS:

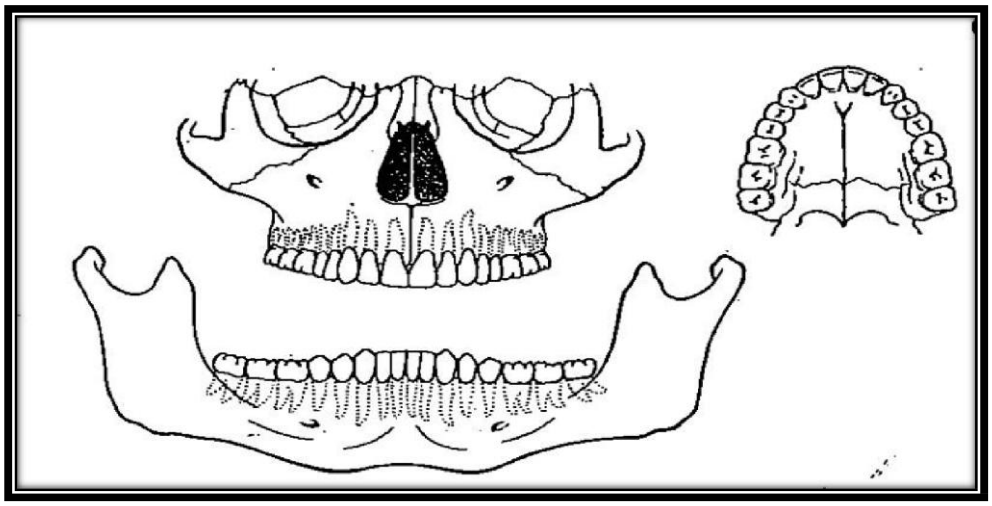
INVESTIGATION:

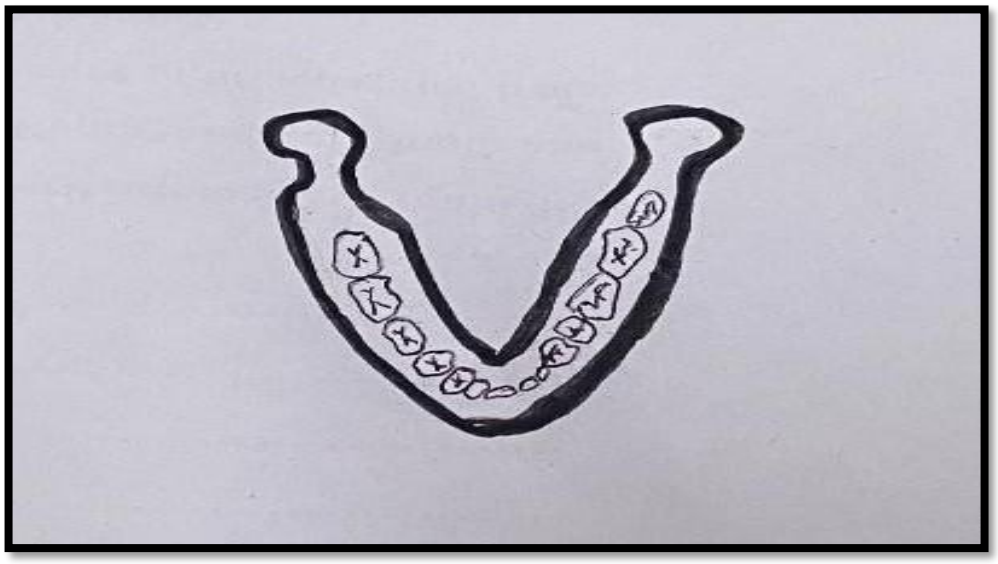
FINAL DIAGNOSIS:

TREATMENT PLAN:

PICTORIAL REPRESENTATION OF FACIAL INJURIES



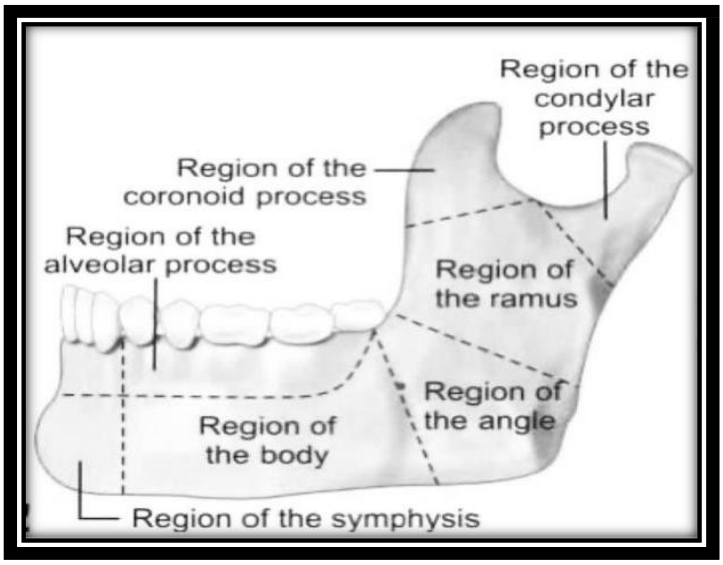




MANDIBULAR FRACTURES CLASSIFICATION

1. Simple
2. Compound
3. Comminuted
4. Complicated
5. Impacted
6. Greenstick
7. Pathological

- **Anatomical location:**


Region of the condylar process
Region of the coronoid process
Region of the alveolar process
Region of the ramus
Region of the angle
Region of the body
Region of the symphysis

- **Based on teeth in relation to the fracture line:**

1. Class I – Teeth are present on both sides of the fracture line
2. Class II – Teeth are present only on side of the fracture line
3. Class III – Patient is edentulous

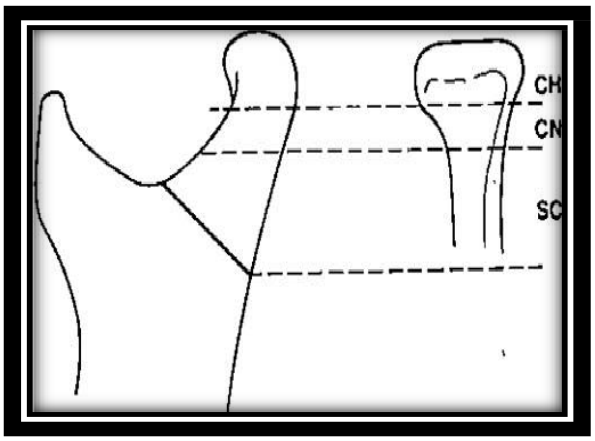
Based on direction of fracture line:

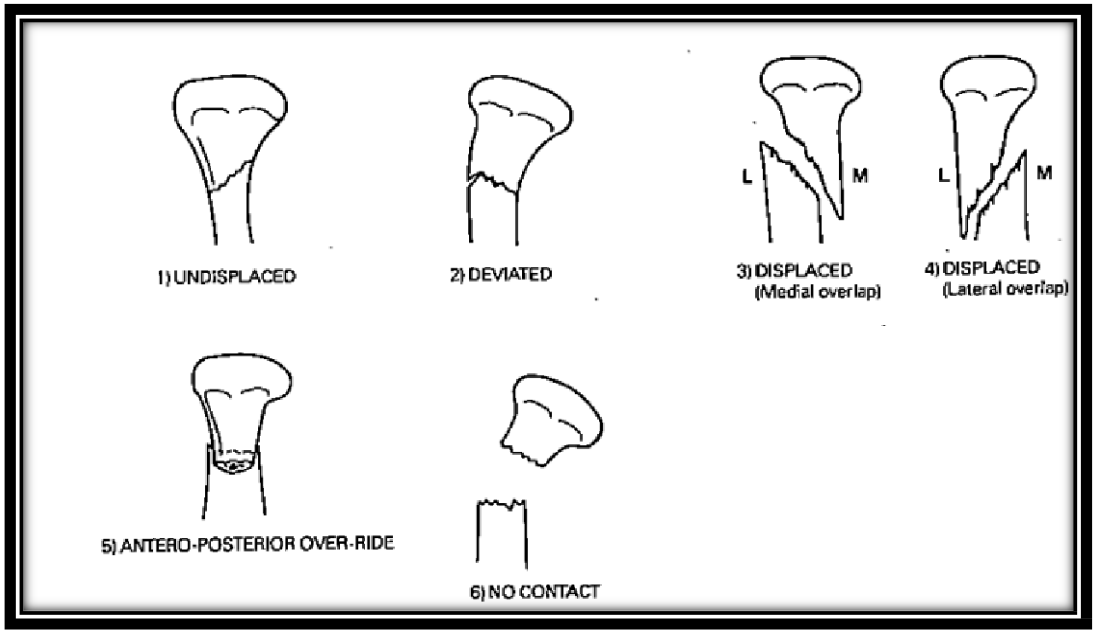
i. Favorable fracture
ii. Unfavorable fracture

- **SORG Classification (2007)**

1. Di-capitular fracture (i.e. through the head of the condyle (DF)
2. Fracture of the Condylar Neck (CN)
3. Fracture of the Condylar Base (CBF)

- **Lindhall Based on level of Fracture (1977)**





ANNEXURE – 4

POST-OPERATIVE ASSESSMENT

BITE FORCE MEASUREMENTS

PATIENT NAME: DATE:

AGE:

SEX:

DIAGNOSIS:

GROUP: 1/2

FOLLOW UP	INCISOR REGION	LEFT MOLAR REGION	RIGHT MOLAR REGION
	CONTROL VALUE:	CONTROL VALUE:	CONTROL VALUE:
1st WEEK			
3rd WEEK			
6th WEEK			
9th WEEK			

ANNEXURE - 5

INFORMED CONSENT

DEPARTMENT OF ORAL AND MAXILLOFACIAL SURGERY

SANTOSH DENTAL COLLEGE AND HOSPITAL, GHAZIABAD

"COMPARATIVE EVALUATION OF PERIOD REQUIRED FOR RECOVERY OF MAXIMUM BITE FORCE FOLLOWING OPEN AND CLOSED REDUCTION OF MANDIBULAR FRACTURE: A PROSPECTIVE CLINICAL STUDY"

I, Mr. / Ms. ……..

S/O, D/O, W/O. …….....

Resident of …….....

have been informed about all the benefits and risks during and after the surgical procedure. I am willingly participating in the study conducted by the department of Oral and Maxillofacial Surgery, Santosh Dental College and Hospital.

I should choose to withdraw from this study at any point; I will be free to do so after giving prior information to the concerned surgeon.

Signature of Surgeon In-charge
Date:

Signature of Patient
Date:

Signature of
Parent/Guardian
Date:

शोध विषयस्वीकृवि पत्र

ओरल एंड मैक्सिलोफेशियल सर्जरी विभाग

संतोष डेंटल कॉलेज एंड हॉस्पिटल, गाज़ियाबाद

"मैंडिबुलर फ्रैक्चर के ओपन और क्लोज़्ड रिडक्शन के बाद अधिकतम बाइट फोर्स की पुनर्प्राप्ति में लगने वाले समय का तुलनात्मक मूल्यांकन: एक संभावित नैदानिक अध्ययन"

मैं, श्री / श्रीमती / सुश्री .....

पुत्र / पुत्री / पत्नी.....

निवासी: .....

मुझे सर्जिकल प्रक्रिया के दौरान और उसके पश्चात होने वाले सभी लाभों और जोखिमों के बारे में पूरी जानकारी दी गई है। मैं इस अध्ययन में अपनी स्वेच्छा से भाग ले रहा/रही हूँ, जो कि ओरल एंड मैक्सिलोफेशियल सर्जरी विभाग, संतोष डेंटल कॉलेज एवं हॉस्पिटल द्वारा किया जा रहा है।

यदि मैं किसी भी समय इस अध्ययन से नाम वापस लेना चाहूँ, तो मैं संबंधित सर्जन को पूर्व सूचना देकर ऐसा करने के लिए स्वतंत्र हूँ।

जिम्मेदार सर्जन के हस्ताक्षर

रोगी के हस्ताक्षर

अभिभावक / संरक्षक के हस्ताक्षर

ANNEXURE - 6

MASTER CHART

GROUP A (ORIF)					POSTOPERATIVE BITE FORCE MEASUREMENTS (IN NEWTONS): GROUP A (ORIF)											
SN	NAME	DIAGNOSIS	AGE	SEX	IR				RMR				LMR			
					W1	W3	W6	W9	W1	W3	W6	W9	W1	W3	W6	W9
1	LALIT KUMAR	LT PARASYMPHYSIS & RT ANGLE #	36	M	44.24	122.72	128.77	125.06	97.34	213.3	256.38	382.72	162.54	251.26	236.59	231.7
2	AVINASH TYAGI	LT PARASYMPHYSIS #	32	M	50.3	40.98	72.38	92.4	107.35	234.03	235	240	149.26	107.58	110.68	215.39
3	CHANDRAMOHAN JHA	RT CONDYLAR & LT ANGLE #	34	M	108.25	158.32	160.1	165.36	248.45	280.23	300.32	330.46	209.3	230.9	248.7	305.63
4	MITHUN	RT PARASYMPHYSIS & LT ANGLE #	27	M	40.75	34.46	35.9	90.25	95.01	82.9	95.47	129.35	61.71	91.51	86.86	124.24
5	JITENDER	LT MANDIBULAR BODY #	30	M	110.3	130	140.9	160.8	210.5	230	290.1	340.6	100.2	190.3	240.39	255.78
6	MAYANK	RT MANDIBULAR ANGLE #	21	M	49.13	150.2	167.89	171.62	118.53	125.51	130.4	153.22	136.22	164.63	211.9	224.48
GROUP B (CR)					POSTOPERATIVE BITE FORCE MEASUREMENTS (IN NEWTONS): GROUP B (CR)											
SN	NAME	DIAGNOSIS	AGE	SEX	IR				RMR				LMR			
					W1	W3	W6	W9	W1	W3	W6	W9	W1	W3	W6	W9
1	MUSKAAN	LT MANDIBULAR BODY #	23	F	35.39	75.45	116.9	108.28	112.24	210.51	235.66	230.07	27.71	193.04	227.97	225.41
2	EDWIN	LT MANDIBULAR ANGLE #	20	M	24.22	44.24	62.41	103.16	64.04	87.79	98.73	130.4	58.22	73.58	99.2	150.89
3	AMAR	RT PARASYMPHYSIS #	31	M	10	60.34	94.35	102.05	110.45	220.35	247.39	225.34	120.23	240.35	260.8	255.74
4	VISHWAAS	RT PARASYMPHYSIS #	23	M	25.22	62.34	110.3	115.69	125.37	155.69	210.1	286.2	134.37	167.31	220.36	295.39
5	ANUJ	SYMPHYSIS #	22	M	20.3	70	130.9	150.5	120.6	270.35	290.1	320.9	122.2	160.3	279.18	285.9
6	PUNIT TULI	B/L MANDIBULAR BODY #	26	M	40.02	89.27	115.78	125.34	110.67	175.34	160.45	170.23	107.87	168.73	172.76	189.23

ORIF - OPEN REDUCTION AND INTERNAL FIXATION

RT - RIGHT LT - LEFT

CR - CLOSED REDUCTION

- FRACTURE

IR - INCISOR REGION RMR - RIGHT MOLAR REGION LMR - LEFT MOLAR REGION

W1- WEEK 1
W3- WEEK 3
W6- WEEK 6
W9- WEEK 9